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Geology of the

Houghton-Hough Lakes Area

(Savant Lake Area)

By

W.D. Bond

1980

Ontario

Ministry of Natural Resources

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Geological Map

(back pocket)

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Chart

(back pocket)

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CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

If the reader wishes to convert imperial units to SI (metric) units or SI units to imperial units the following multipliers should be used:

CONVERSION FROM SI TO IMPERIAL			CONVERSION FROM IMPERIAL TO SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
			LENGTH		
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
			AREA		
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
			VOLUME		
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
			CAPACITY		
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
			MASS		
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
			CONCENTRATION		
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

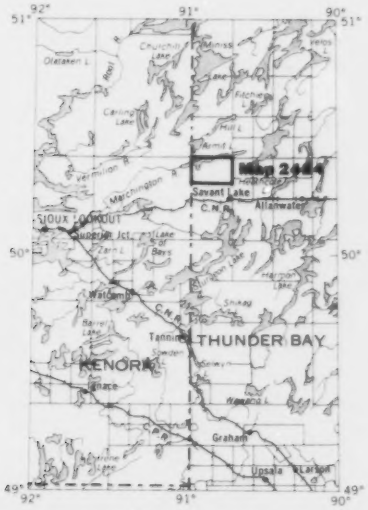
OTHER USEFUL CONVERSION FACTORS

1 ounce (troy)/ton (short)	20.0	pennyweights/ton (short)
1 pennyweight/ton (short)	0.05	ounce (troy)/ton (short)

NOTE–Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries published by The Mining Association of Canada in co-operation with the Coal Association of Canada.

ABSTRACT

The Houghton-Hough Lakes area comprises 239 km² and is situated in the Savant Lake area, District of Thunder Bay. The map-area, lying approximately 245 km north-northwest of Thunder Bay, straddles the contact of the English River Subprovince and the Wabigoon Subprovince. Both of these form part of the Superior Province of the Precambrian Shield in northwestern Ontario. The area falls largely within the Wabigoon Subprovince. All of the bedrock underlying the map-area is of Early Precambrian (Archean) age and is overlain by unconsolidated Quaternary glacial, glaciofluvial, and Recent deposits.



SMC 14172

Figure 1–Key map showing location of Houghton-Hough Lakes Area. Scale 1:3 168 000 (1 inch to 50 miles).

Metavolcanics and metasediments of the Savant Lake Greenstone Belt occupy the greater part of the map-area and form two distinct volcanic sequences. The first volcanic sequence, situated north of Kashaweogama Lake, is composed of massive and pillowed mafic volcanic flows that are equivalent to the Jutten Volcanic Sequence exposed in McCubbin Township (Bond 1979) and Jutten Township (Bond 1979). The Jutten Volcanic Sequence is believed to be the oldest stratigraphic sequence in the Savant Lake belt. In the Houghton-Hough Lakes area, a fairly thick chert-iron-silicate formation is interlayered within the 'Jutten Volcanic' sequence. The second volcanic sequence lies south of Kashaweogama Lake and comprises a complex interlayered succession of mafic, intermediate, and felsic metavolcanics locally intercalated with arenaceous, argillaceous, and ferruginous metasediments.

This succession is continuous with the volcanic sequence in Conant Township referred to by Rittenhouse as the 'Handy Lake Volcanics' and is herein referred to as the Handy Lake Volcanic Sequence. In the early stage of development of the Handy Lake Volcanic Sequence, volcanic activity was interrupted by local, minor periods of sedimentation. In the later stages waning volcanism was punctuated by substantial periods of quiescence during which thick and extensive clastic sediments and chemical sediments in the form of iron formation were deposited. The chemically deposited, syngenetic iron formation is intimately interbedded with the clastic metasediments. The Handy Lake Volcanics are predominantly comprised of fine-grained pyroclastic debris and local flow units.

Within the Houghton-Hough Lakes map-area, the Jutten Volcanic Sequence faces northeast. These rocks have undergone an early period of deformation which resulted in overturning of the sequence prior to deposition of conglomerate and related finer grained clastic metasediments. The conglomerate and related finer metasediments are unconformably deposited on the overturned Jutten Volcanic Sequence and are believed to face south towards the north facing Handy Lake Volcanic Sequence. The latter show no evidence of this early period of deformation implying that they are younger in age than the Jutten Sequence. The conglomerate is partly discordant to the trend of the formations within the Handy Lake Volcanic Sequence due to faulting.

The Jutten Volcanic Sequence has been intruded by plutonic rocks of relatively uniform (granodiorite to quartz monzonite) composition. Intrusive phases within the Handy Lake Volcanic Sequence are more diversified in composition ranging from subvolcanic porphyritic phases in the earliest stages, to gabbro to granodiorite in the later stages.

The area has been complexly deformed by both faulting and folding. In the map-area the two volcanic sequences are separated by the Kashaweogama Lake Fault which is characterized by cataclasis and minor pseudotachylite. These cataclastic features are especially prominent within the intrusive complex at Fairchild Lake which is part of the Southern Plutonic Domain of the English River Subprovince. The Handy Lake Volcanic Sequence south of Kashaweogama Lake occupies the west limb of an isoclinally folded anticlinal sequence that faces north and east and plunges 50 to 70 degrees to the east-northeast.

Minor gold, silver, and copper occurrencea are locally associated with epigenetic quartz veins in the Jutten Volcanic Sequence but, to date, major deposits of this type have not been discovered. The Handy Lake Volcanic Sequence south of Kashaweogama Lake contains local concentrations of copper, lead, silver, minor gold, and molybdenum and exhibits many characteristics similar to known base metal volcanogenic stratiform ore deposit environments. Iron associated with chert-magnetite iron formation is concentrated in the northeastern part of the map-area and may eventually be of recoverable grade.

Geology
of the
Houghton-Hough Lakes Area
(Savant Lake Area)
District of Thunder Bay

by

W.D. Bond[1]

INTRODUCTION

Location and Access

The Houghton-Hough Lakes map-area is situated approximately 245 km north-northwest of Thunder Bay. The map-area is limited in the north by the 7th Base Line (Latitude 50°24′40″N) and in the south by Latitude 50°18′00″N. The western boundary of the map-area coincides with the western boundary of the Thunder Bay District (Longitude 90°57′52″W) and the eastern boundary coincides with the western boundaries of Conant and Boucher Townships (Longitude 90°41′33″W); the area totals 239 km^2.

The town of Savant Lake, situated at the junction of the Canadian National Railways and Highway 599, is located about 8 km south of the southeast corner of the map-area. Highway 599 originates at a point 1.6 km east of the town of Ignace (242 km west of Thunder Bay) and extends northeast passing by the town of Savant Lake after 145 km. This highway continues northward, passing through the extreme southeastern part of the map-area. Several poor logging roads extend out from Highway 599 near Evans Lake and provide partial access into the southeast part of the map-area. Most of these logging roads, however, are accessible only on foot. A road was proposed in 1974 to extend eastward from Sioux Lookout to intersect Highway 599 near Evans Lake. This road, completed in 1977, passes near the north shore of Patterson Lake, the south shore of Houghton Lake, and continues west-southwest out of the map-area giving access

[1]Geologist, Geological Branch, Division of Mines. Manuscript accepted by the Chief Geologist, 8 February, 1978. This report is published with the permission of E.G. Pye, Director, Ontario Geological Survey.

to much of the southern part of the map-area. This road was not present during the 1973 field season but has been added to Map 2424 (back pocket). Outcrop exposures along or near the road are not tied to the road location.

Access into the northern and eastern parts of the map-area can be made by canoe, boat, or fixed-wing aircraft based out of the town of Savant Lake. Kashaweogama Lake in the north, extends east-northeast into McCubbin Township (Bond 1975) where it terminates near an access road that extends west from Highway 599 at a point approximately 23 km north of the town of Savant Lake. A short set of rapids with a portage links Kashaweogama Lake to Fairchild Lake. A short portage (approximately 75 m) also links Fairchild Lake to Moosolf Lake. Fixed-wing aircraft provides access into the remainder of the area including Bowl Lake, Hough Lake, Patterson Lake, Exploration Lake, Island Lake, and the small lake situated approximately 4 km west of Evans Lake.

Field Mapping Procedure

Field work for the present survey was done during the summer of 1973. Mapping was done by pace-and-compass traverses done at ¼ mile intervals, supplemented by vertical air photographs (scale 1:15 840, 1 inch to ¼ mile). Traverses were designed for optimum coverage of outcrops as interpreted through previous air photograph examination and were run at or near right angles to the known trend of the lithological formations. Outcrop mapping was done where the exposure was sufficient to be apparent on the airphotos and these were marked directly on a photo overlay. Outcrop not apparent on the airphotos were related to recognizable topographic features by pace-and-compass lines. In addition, all shorelines of lakes and rivers and all roads were examined. Over areas underlain by iron formation, standard compasses were found to be useless and structural trends in these areas were approximated using the sun in conjunction with recognizable topographic features.

Geological data were plotted in the field on transparent overlays attached to the airphotos and subsequently were transferred to a base map prepared by the Cartography Section of the Lands and Waters Group from maps of the Forest Resources Inventory, Ontario Ministry of Natural Resources.

A preliminary uncoloured geological map (Bond 1974) supplemented with marginal notes was published at a scale of 1:15 840 (1 inch to ¼ mile). A final coloured map (see back pocket) at a scale 1:31 680 (1 inch to ½ mile) accompanies this report.

Acknowledgments

Capable assistance in the field was provided by T. Buckley, D. Desnoyers, M.A. Guttman, and C. Idziszek. Mr. Idziszek, as senior assistant, was responsible for approximately 50 percent of the geological mapping and the author also acknowledges him for numerous discussions during the field season.

N.F. Trowell, a colleague working in the adjoining area southeast of the

map-area is acknowledged for numerous geological discussions, and for providing data on the Savant Lake Prospect.

R. Pichette contributed to the preparation of the figures and some of the modal analyses. All chemical analyses were completed by the staff of the Geoscience Laboratories, Ontario Geological Survey.

Previous Geological Mapping

According to E.S. Moore (1928) the first reference to Savant Lake in the literature was by G.W. McInnes (1901) who reported traces of gold occurring on one of the islands in Savant Lake. T.W. Gibson (1902, p.18) and W.G. Miller (1903) also reported the presence of gold in the Savant Lake area. W.H. Collins (1907; 1910) was the first to conduct a geological reconnaissance of the area and published a map (Collins 1910, accompanying Map 993) at a scale of 1:253 440 or 1 inch to 4 miles. Moore (1910) visited the area in 1909 to evaluate the iron deposits and published a map at a scale of 1:126 720 or 1 inch to 2 miles. The Savant Lake area was brought into prominence by a major gold rush in 1926. As a consequence, the following year, Moore (1928, Map 37j) conducted a semi-detailed geological survey of the Savant Lake area; the resulting map was published at a scale of 1:126 720 or 1 inch to 2 miles. His mapping accurately defined the contact of the granitic intrusives and the mafic metavolcanics north of Kashaweogama Lake and also delineated the conglomerate along Kashaweogama Lake. The rocks south of Kashaweogama Lake, however, remained largely unsubdivided at this time. G. Rittenhouse (1936) mapped four of the townships adjoining the east part of the map-area and P.P. Hudec (1965) did a reconnaissance (scale 1:63 360 or 1 inch to 1 mile) of the area adjoining the west part of the north boundary of the map-area. J.C. Davies *et al.* (1970) did a compilation of the entire region and the resulting map was published at a scale of 1:253 440 or 1 inch to 4 miles. R. Skinner (1969) mapped the area at a reconnaissance scale 1:253 440 or 1 inch to 4 miles for the purpose of correlating the surrounding greenstone belts but again much of the map-area south of Kashaweogama remained unsubdivided. The three adjoining townships to the east of the present map-area (Conant, Jutten, and Smye Townships) were mapped in detail at a scale of 1:15 840 or 1 inch to ¼ mile by the author (Bond 1973a, b, c) during the 1972 field season.

Prospecting and Mining Activity

Recorded geological exploration in the Savant Lake area dates back to about the turn of the century when gold was sought by the early prospectors. Several gold rushes have occurred in the Savant Lake area but have not affected the present map-area. Evidence of early exploration activity within the Houghton-Hough Lakes map-area is restricted to a few isolated test pits and strippings along Kashaweogama Lake. Extensive iron deposits were discovered west of the main part of Savant Lake during the very early part of the century. The iron de-

posits are in the form of iron formation intercalated with arenaceous metasediments. They are mostly concentrated (through folding) just outside the extreme northeast corner of the Houghton-Hough Lakes map-area.

Since the mid 1950s emphasis in exploration has shifted from precious metals to base metal deposits. The discovery of the Mattabi Mine on nearby Sturgeon Lake in 1968 reactivated interest in the area. Airborne geophysical surveys have been flown over the present map-area but extensive overburden and limited access have continued to hamper exploration activities.

Topography and Drainage

Outcrop exposures in the Houghton-Hough Lakes area tend to be limited in extent due to considerable accumulations of glacial till and esker deposits. Fluctuations of 30 to 60 m in the topography can be directly related to the thickness of the glacial deposits. The topographical low is situated at Kashaweogama Lake, and lies just below 1,300 feet above sea level. South of Kashaweogama Lake, the topography rises progressively higher reaching a maximum in the southeast. The area from Kashaweogama Lake south to Hough Lake and Houghton Creek generally lies between 400 and 425 m. The southern part of the map-area lies above 425 m and locally the topography rises to over 450 m south of Hough Lake and in the southeastern part of the map-area just north of Evans Lake where a Bench Mark indicates an altitude of 1,517.5 feet.

Some of the lakes trend subparallel to the direction of ice movement whereas still others appear to be fault controlled. Outcrop density is fairly uniform throughout the map-area except in the areas covered by the eskers and their related outwash deposits. Good exposures are available on the shorelines of most lakes but are not particularly abundant.

The map-area is located within the headwaters of the English River Drainage Basin and is part of the Arctic watershed. Except for Evans Lake and the small lake situated 4 km west of Evans Lake, all of the lakes drain into Kashaweogama Lake which drains southwestward towards Sioux Lookout. The small lake 4 km west of Evans Lake is drained by Barnard Creek which flows southward to Barnard Lake to eventually join up with the Sturgeon River which is also part of the English River Drainage Basin. Evans Lake drains southward into the North Arm of Sturgeon Lake and thence into the Sturgeon River. Rapids are common along many of the river channels separating the lakes; their gradients are gentle, controlled in many areas by beaver dams. The Marchington River rapids between Fairchild and Kashaweogama Lakes are navigable by canoe or boat. Most of the rivers are too small to be navigable by canoe and many of their courses are blocked by overhanging and fallen trees.

GENERAL GEOLOGY

Early Precambrian (Archean)

The Houghton-Hough Lakes map-area is underlain by rocks that are all Early Precambrian (Archean) in age. The map-area straddles the boundary of the Wabigoon and English River Subprovinces of the Superior Province of the Canadian Shield. Two distinct sequences of supracrustal rocks that are separated by faulting are present in the map-area.

The first sequence, situated north of Kashaweogama Lake, is comprised of mafic metavolcanic flows with an intercalated cherty metasedimentary formation and forms a belt approximately 1280 m wide. These mafic metavolcanics are equivalent to the 'Jutten Volcanics' (Rittenhouse 1936; see Table 2) exposed in McCubbin Township (Bond 1977) and Jutten Township (Bond 1976). Locally, the presence of pillow lavas indicates this sequence to be subaqueous in origin. Polymictic conglomerate characterized by granitoid (trondhjemite) and volcanic clasts is unconformably deposited on this first sequence.

The second sequence, situated south of Kashaweogama Lake, is a complex, layered succession of mafic, intermediate, and felsic metavolcanic formations with minor intercalated metasedimentary formations. This sequence resembles an "upper volcanic cycle" considered typical of advanced evolutionary development of a standard Archean volcanic sequence as observed in other Early Precambrian volcanic successions (Morrice 1974). This sequence is laterally continuous with that in Conant Township (Bond 1973a) which Rittenhouse (1936) first referred to as the "Handy Lake Volcanics" and is herein termed the "Handy Lake Volcanic Sequence". The Handy Lake Volcanic Sequence is composed of volcanic flows and pyroclastics of variable composition interrupted locally by metasedimentary units which are more prevalent towards the top. The predominantly fine-size fraction of the pyroclastic material combined with the association of extensive, bedded metasedimentary units indicate that, within the map-area, the Handy Lake Volcanic Sequence represents a distal facies environment. The two most northern metasedimentary bands exposed in the map-area are laterally continuous with a thick sedimentary succession exposed mainly in McCubbin and Poisson Townships (Bond 1977) situated east-northeast of the map-area (Figure 5, see Chart A, back pocket). This thick metasedimentary succession was termed the 'Savant Series' by Rittenhouse (1936) and was grouped with the volcanics now termed as the Handy Lake Volcanic Sequence in a 'Savant Group' by Moore (1928). In this report the term Savant Group will be used to refer to only the metasediments within or laterally continuous with the main metasedimentary succession exposed in McCubbin and Poisson Townships; the conglomerate is included in this group. That is, the Savant Group does not include those metasedimentary formations that are entirely within the Handy Lake Volcanic Sequence. Within the map-area no repetition of lithologic units attributable to folding appears to be present in the Handy Lake Volcanic Sequence although there are few specific marker horizons to assure this. Assuming no folding, it is estimated that this sequence (within the map-area) varies in thickness from about 4100 m in the west to more than 11 300 m in the east.

TABLE 1 | TABLE OF LITHOLOGIC UNITS FOR THE HOUGHTON-HOUGH LAKES AREA

CENOZOIC

QUATERNARY

RECENT

Swamp, stream and lake deposits

PLEISTOCENE

Glacial till, sand, silt, gravel and boulders

Unconformity

PRECAMBRIAN

EARLY PRECAMBRIAN (ARCHEAN)

FELSIC TO INTERMEDIATE IINTRUSIVE ROCKS

Medium- to coarse-grained massive biotite and chlorite-biotite trondhjemite; fine- to medium-grained trondhjemite; granodiorite; quartz monzonite; foliated to weakly cataclastic, porphyritic augened quartz monzonite to granodiorite; band hybrid, weakly cataclastic and protomylonitic-porphyritic augened quartz monzonite to granodiorite; aplite; pegmatite, migmatite, hybrid trondhjemite

Intrusive Contact

MAFIC TO INTERMEDIATE INTRUSIVE ROCKS

Quartz diorite, locally diorite; quartz diorite to biotite-hornblende trondhjemite gabbro; porphyritic gabbro; peridotite; quartz diorite to locally quartz gabbroic; porphyroblastic (hornblende) mafic to intermediate intrusive rocks

Intrusive Contact

METAMORPHOSED FELSIC TO INTERMEDIATE PORPHYRITIC INTRUSIVE ROCKS

Quartz-feldspar porphyry; feldspar porphyry; feldspar-quartz porphyry, quartz porphyry

Intrusive Contact

METASEDIMENTS

CLASTIC METASEDIMENTS

CONGLOMERATIC METASEDIMENTS

Polymictic volcanic conglomerate

ARENACEOUS AND ARGILLACEOUS METASEDIMENTS

Arkosic greywacke, lithic arkosic greywacke, sandstone; siltstone, mudstone, cherty siltstone, tuffaceous metasediments

CHEMICAL METASEDIMENTS

FERRUGINOUS METASEDIMENTS

Quartz-magnetite iron formation; quartz magnetite iron formation with interbedded arkosic greywacke, lithic arkosic greywacke, siltstone; quartz-magnetite iron formation with interbedded tuffaceous metasediments, lapilli-tuff; quartz-magnetite iron formation with interbedded cherty metasedimenta

Grey chert, white chert, grunerite-bearing cherty siltstone

METAVOLCANICS

FELSIC METAVOLCANICS

Fine-grained massive flows; flow-banded flows; tuff; lapilli-tuff; tuff-breccia; crystal tuff; lapillistone; quartz, quartz-feldspar, and feldspar-quartz porphyry; felsite; porphyritic (feldspar) flows; flow breccia; crystal/lapilli tuff (fragments with cavities); ash flow breccia

INTERMEDIATE METAVOLCANICS

Fine- to medium-grained massive flows; porphyritic (feldspar) flows; tuff; lapilli-tuff; tuff-breccia; crystal tuff; bedded tuff, reworked tuff; mixed metavolcanics (intermediate metavolcanics, locally tuffaceous metasediments with mafic (amphibolitized) metavolcanic clots and lenses); hyaloclastic breccia; unsubdivided intermediate metavolcanics locally with porphyroblastic plagioclase; flow breccia; garnet, staurolite, sericite schist

MAFIC METAVOLCANICS

Fine- to medium-grained massive flows; medium- to coarse-grained massive flows; porphyritic (feldspar) flow; amygdaloidal flows; pillow lavas; tuff; lapilli-tuff, tuff-breccia; mafic metavolcanics derived schists, locally gneisses; flow breccia; porphyritic (amphibole) mafic to intermediate flows; flow breccia.

In the Houghton-Hough Lakes area, both the Jutten Volcanic and the Handy Lake Volcanic Sequences face predominantly north. The strike trend of the Jutten Volcanic Sequence, north of Kashaweogama Lake has been modified by the intrusion of felsic plutonic stocks. The Handy Lake Volcanic Sequence has been intruded by sills of felsic to intermediate porphyritic rocks of subvolcanic origin and subsequently intruded by mafic to felsic plutonic rocks that form sills, stocks, and batholiths.

The Handy Lake Volcanic Sequence has been folded and the map-area occupies the west limb and part of the nose of this fold. Top determinations in the intercalated metasedimentary units face north and the entire sequence forms an anticlinal structure that plunges steeply east to east-northeast. Faulting, in response to the folding event, occurs along the length of Kashaweogama Lake.

Greenschist facies regional metamorphism has affected the rocks in the northern half of the Houghton-Hough Lakes area. Near intrusive rocks upper greenschist to amphibolite facies contact metamorphism prevails. In the southern part of the map-area, the metavolcanics and metasediments have been recrystallized to predominantly amphibolite facies metamorphic rank with the result that many of the primary textures have been obliterated. A subsequent greenschist facies metamorphic event has retrograded the amphibolite metamorphic rank of many of the rocks in this southeastern part of the map-area.

A summarized description of the rock types and formations within the map-area is given in Table 1. Previous investigators (Moore 1928; Rittenhouse 1936; Skinner 1969) established the main geological units and devised their own nomenclature for the various lithologic units. Table 2 summarizes their terminology and shows the correlation between each of their sequences and the stratigraphy of the present survey. With respect to the present survey, the Jutten Volcanic Sequence, north of Kashaweogama Lake is believed to be older than the Handy Lake Volcanic Sequence and is so indicated by the author in Table 2.

TABLE 2 | HISTORY OF STRATIGRAPHIC NOMENCLATURE USED FOR SAVANT LAKE AREA.

MOORE, E.S. (1928)		RITTENHOUSE (1936)			SKINNER (1969)		PRESENT SURVEY	
PRECAMBRIAN:							FELSIC INTRUSIVE ROCKS	
KEWEENAWAN: Diabase dikes		KEWEENAWAN (?) - Diabase dikes			KEWEENAWAN (?) - Diabase dikes		MAFIC INTRUSIVE ROCKS	
ALGOMAN: Granitic Intrusives		Granitic Intrusives			Granitic Intrusives; gneisses		PORPHYRITIC INTRUSIVE ROCKS	
		BASIC INTRUSIVES						
SAVANT GROUP	TIMISKAMING: Complex series of interbanded acid, intermediate and basic lava flows, agglomerates, tuffs, arkose, greywacke, banded iron formation and conglomerate and derived gneisses.	HANDY LAKE VOLCANICS felsic to intermediate volcanics			SAVANT GROUP	HANDY LAKE VOLCANICS	SAVANT GROUP	
		Unconformity						
		SAVANT SERIES	UPPER	Upper Greywacke member		TIMISKAMING (?) Metasediments	Ferruginous and Arenaceous Metasediments	
				Upper Iron-bearing member				
				Lower Greywacke member		Pyroclastics		
				Lower Iron-bearing member				
			LOWER	Upper Conglomerate member			Conglomerate and related metasediments	HANDY LAKE VOLCANIC SEQUENCE Mafic, Intermediate and Felsic Metavolcanics with minor interlayered Ferruginous and Arenaceous Metasediments
				Lower Conglomerate member				
	KEEWATIN: Greenstone, intermediate to mafic metavolcanics	JUTTEN VOLCANICS: Mafic to intermediate metavolcanics			GREENSTONE: Mafic to intermediate metavolcanics		JUTTEN VOLCANIC SEQUENCE Mafic Metavolcanics with interlayered Cherty Metasediments	

METAVOLCANICS

Field Classification

Metavolcanics, including massive flows, porphyritic flows, pyroclastic rocks, and bedded and reworked pyroclastic rocks underlie approximately 65 percent of the map-area. In the field, these rocks were classified into three subdivisions based on colour index: mafic, intermediate, and felsic metavolcanics. Colour index is the percentage of mafic minerals including amphibole, biotite, and chlorite that are present in the rock; it is best observed near the base of the weathered rind as seen on a fresh surface. Mafic metavolcanics are characterized by a colour index greater than 40 and include volcanic rocks of basaltic composition. Intermediate metavolcanics are characterized by a colour index between 40 and approximately 18 percent and include volcanic rocks of andesitic and dacitic composition. Felsic metavolcanics have a colour index less then 18 percent and include volcanic rocks of rhyolitic, and upper dacitic compositions. The mafic minerals in the felsic metavolcanics are commonly not apparent due to the fact that they are too fine grained to be observed in the field. Thus, many of the rocks classified in the felsic subdivision in the field actually appeared to contain less than 5 percent visible mafic minerals. At a few localities the colour index was found to overlap the felsic-intermediate subdivision boundary and these are indicated by the codes 2j (intermediate to felsic) and 3j (felsic to intermediate) in the map legend.

The majority of the contacts within the metavolcanic sequence mark changes in composition that correspond to one of the three subdivisions. Locally, internal contacts within individual subdivision units delimit texturally distinct units of similar composition. The Handy Lake Metavolcanic Sequence is composed predominantly of intermediate to felsic metavolcanics. In the southeastern part of the map-area the intermediate and felsic metavolcanics are complexly intermixed and some of the map units shown are based on the predominant composition present. Several of the felsic metavolcanic formations are extensive and, partly due to lack of sufficient exposure, probably contain more intermediate metavolcanic material than indicated on the map.

Mafic Metavolcanics

Mafic metavolcanics form five distinct formations in the map-area. The mafic metavolcanics exposed north of Kashaweogama Lake are probably continuous with mafic metavolcanics in northern McCubbin Township (Bond 1977) and are believed by the author to be equivalent to Rittenhouse's 'Jutten Volcanics' (see Table 2). These volcanics appear to be the oldest rocks in the Savant Lake area. In the Houghton-Hough Lakes area, this Jutten Volcanic Sequence, including intercalated cherty metasediments, is a maximum 1300 m wide but thins rapidly away from this maximum due to modification by granitic intrusion and faulting along Kashaweogama Lake. South of Kashaweogama Lake there

are four separate mafic metavolcanic formations that form layered units within the predominantly felsic to intermediate Handy Lake Volcanic Sequence. The most prominent formation is continuous across the map-area from Hough Lake to Fairchild Lake and varies from 1800 m near the centre of the unit down to 600 at the margins of the map-area. The other formations are more discontinuous with the more southerly formation near Barnard Creek (outside map-area) being abruptly terminated by faulting. The clots within the mixed volcanic unit discussed later in this report (map code 2h) are also mafic in composition.

MINERALOGY

The mafic metavolcanics have been derived from rocks of predominantly basaltic composition (Figure 2, analysis number 1; Bond 1979, p.12). These rocks weather light green to dark green and vary from green to dark green to almost black on the fresh surface. Thin section examination indicates the typical mineral assemblage in the greenschist facies is metamorphically derived actinolite + plagioclase (albite-oligoclase) ± hornblende ± epidote ± clinozoisite ± quartz ± sericite (rare) ± carbonate. Chlorite is commonly associated with quartz veins and is mostly hydrothermal in origin. Opaque minerals (mainly pyrite, pyrrhotite), sphene, and leucoxene are fairly common accessories. In the almandine-amphibolite facies that is prevalent near the southeastern corner of the map-area hornblende becomes more prominent at the expense of actinolite, and garnet is also abundant.

Actinolite commonly occurs as single subhedral to euhedral prismatic crystals (0.1 to 2.0 mm) and as aggregates of randomly oriented prismatic crystals. The latter form mats that are 4 to 5 mm across. Locally the actinolite forms single, equant, porphyroblastic crystals (3 to 4 mm), some of which contain randomly oriented plagioclase laths (0.75 mm) preserved in the original ophitic texture, and these single crystals are pseudomorphic after pyroxene. The actinolite is generally randomly oriented but is subaligned in zones of shearing; locally, the foliation wraps around the larger porphyroblastic actinolite that is pseudomorphic after pyroxene. Locally, a gneissic structure defined by discontinuous, alternating actinolite-rich and quartz-feldspathic-rich bands is observed.

Plagioclase (mainly albite-oligoclase) is the other main constituent and forms 30 to 40 percent of these rocks. It is generally untwinned and recrystallized to granular albite (0.2 mm) near the margins of the metavolcanic-metasedimentary belt and is hard to distinguish from recrystallized quartz. Locally, in the centre of the map-area away from the metamorphic affects of the plutonic rocks, the original lath shape of the plagioclase is preserved.

Hornblende is locally developed in the greenschist facies mafic metavolcanics and is locally observed mantling single actinolite crystals where it represents a metamorphic prograde. The hornblende is most prominent in the almandine-amphibolite facies where it is commonly associated with garnet as exhibited by the mafic clots in the mixed volcanic unit (map code 2h).

Epidote, clinozoisite, and, to a lesser extent carbonate and sericite are accessory minerals formed during metamorphic alteration. The epidote and clinozoisite form as subhedral to euhedral crystal aggregates. The porphyritic plagioclase

observed in some of the mafic volcanic flows is always completely altered to clinozoisite. Some of the carbonate and quartz is secondary forming crosscutting veinlets. (Secondary carbonate veinlets are especially prevalent in the mafic volcanics north of Kashaweogama Lake and in the mafic volcanic formation just south of Hough Lake). Radiating, fan-shaped prochlorite is commonly associated with the secondary quartz-carbonate veinlets. Sphene is also a common alteration product.

Massive, fine- to coarse-grained flows are the most common type of flow unit within the map-area. Porphyritic and amygdaloidal flows are locally present but are minor constituents. Pillow lavas, relatively common in the 'Jutten Volcanics' exposed in McCubbin and Jutten Townships, are relatively scarce in the mafic volcanic sequence north of Kashaweogama Lake. Pillow lavas are also rare in the mafic metavolcanic formations interlayered in the volcanic-sedimentary sequence south of Kashaweogama Lake. A few localities of mafic pyroclastic rocks are locally observed along Kashaweogama Lake.

MASSIVE FLOWS

Massive flows are predominantly fine to medium grained but coarse-grained varieties are predominant near the eastern margin of the map-area in the mafic metavolcanic formation just south of Hough Lake. There, the grain size of the amphibolite attains a maximum of 4 to 5 mm. Due to the metamorphic origin of the mineral assemblages in these rocks the extent to which the present grain size reflects the original grain size is not known. The coarser grained mafic flows may, in part, be intrusive into the mafic metavolcanics and may represent vent source zones that were coeval with the extrusive equivalents. Grain size commonly varies from fine to coarse grained over the space of single exposures. It is difficult to estimate the thickness of the flows as no actual contacts were observed in the field. In some places the grain size is uniform across extensive exposures indicating fairly thick flows (30 to 50 m) although some of these may be composed of multiple flows. Amphibole is the most prominent mineral observed in the field and was used as an indicator of grain size; it is generally randomly oriented to locally weakly aligned along secondary shear zones. Locally, the amphibole is subaligned and concentrated forming discontinuous, arcuate swirls that may, in part, represent original flow lines within the lava. Also, a discontinuous gneissic structure, characterized by mafic-rich bands accentuated by discontinuous leucocratic lenticles to bands ranging in width from 1.25 to 3.75 mm, is locally present in some of the mafic volcanic flows. Disseminated pyrite and pyrrhotite are common accessories in these rocks; locally, they are concentrated as veinlets and stringers commonly associated with shear zones. Magnetite is also anomalously concentrated but is not as common as the sulphide mineralization.

North of Kashaweogama Lake the mafic volcanic flows are well foliated to strongly schistose especially near the contact of the two granitoid intrusions.

PORPHYRITIC AND AMYGDALOIDAL FLOWS

Massive porphyritic flows containing plagioclase phenocrysts are locally associated with the massive flows described above. The plagioclase phenocrysts are generally subrounded to subangular and vary from 1 to 8 mm in maximum dimension. Thin section examination shows the porphyritic plagioclase to be single crystals that are completely saussuritized. Contacts between the porphyritic and massive flows were only rarely observed in the field and, due to lack of continuous exposure, the thickness of the porphyritic flow units is unknown. Generally, the porphyritic flows are traceable across only single outcrops. North of Kashaweogama Lake, within the mafic metavolcanic sequence near the contact of the felsic intrusion at Fairchild Lake, several multiple porphyritic flows are exposed. These flows vary from 3 to 9 m thick and are separated by contorted, schistose, locally banded mafic metavolcanics that can be interpreted as possible flow breccia but may also be of tuffaceous origin.

Approximately 450 m northwest of Shoehorn Lake a thin mafic to intermediate porphyritic flow (map code 1j) containing porphyritic actinolite crystals (1 to 2 mm) is exposed. The actinolite crystals form 10 to 15 percent of the rock and are distinctive in the field. Thin section examination reveals the crystals are randomly oriented, generally single to rarely twinned crystals and are roughly square to six-sided to subrounded in form. The nature of the actinolite crystals infers them to be pseudomorphic after pyroxene.

Amygdaloidal flow was found in only one locality near the south end of the small lake situated about 2.7 km west of Evans Lake near the south boundary of the map-area. The amygdules are between 0.63 to 1.25 cm in cross section and are composed of quartz. In the field, the quartz amygdules weather positively giving a knobby texture to the weathered surface. The amygdaloidal flow is exposed on two separate outcrops 300 m apart and appears to be continuous over this distance.

PILLOWED FLOWS

Pillowed flow units are rarely developed in the mafic volcanic formations in the map-area and occur at only three localities, each being in a separate mafic volcanic formation. Well-formed pillows indicating tops to the north are found (1) on the south shore of the small lake situated just north of Kashaweogama Lake in the north-central part of the map-area and (2) approximately 0.8 km north of the northeast part of Houghton Lake. Poorly formed pillow lavas that give no indication of stratigraphic tops were also observed in the thick mafic volcanic formation approximately 3.0 km south of the rapids in the Marchington River between Fairchild and Kashaweogama Lakes. Most of the pillows are bun-shaped and are from 1.2 m to 2.4 m in length. Generally, the pillows are tightly packed and commonly accentuated by a negatively weathered matrix.

PYROCLASTIC ROCKS

Mafic pyroclastic rocks were found in several of the mafic volcanic formations. Based on R.V. Fisher's (1966) classification, mafic tuff, lapilli-tuff, and tuff-breccia were recognized but, because these rocks form only a minor constituent of the mafic volcanic formations, these three classifications are grouped under a single map-unit. The classification of rocks as mafic tuff is somewhat tentative due to the difficulty in distinguishing them from fine- to medium-grained mafic flows. In general, the mafic tuffs are more prominently foliated than the latter. Due to the coarser grain size of the fragments, lapilli-tuff and tuff-breccia are more easily recognized. The coarsest mafic pyroclastic rocks, consisting of mafic fragments (20 to 30 cm in length) in a mafic matrix, are exposed in the mafic volcanic formation west of the small lake, 4 km west of Evans Lake. The mafic fragments are similar in composition to and tend to blend into the matrix, but the presence of a few felsic fragments indicate the pyroclastic origin. Mafic tuff and lapilli-tuff are also exposed on the northeast shore of Kashaweogama Lake and on several nearby islands but there the fragments are obscured by intense shearing and injection of quartz and carbonate veinlets. Rare thin mafic lenses that are interpreted to be tuff horizons are locally present within the felsic metavolcanics near Evans Lake.

SUMMARY

In summary, the mafic metavolcanics are composed of volcanic rocks of basaltic composition. They are most easily recognized by a colour index of greater than 40 and are generally dark green on the weathered surface. They occur predominantly as multiple, massive, mafic flow units that form five separate formations within two different sequences in the map-area.

Intermediate Metavolcanics

Intermediate metavolcanics are estimated to underlie approximately 35 to 40 percent of the map-area and include rocks of andesitic and dacitic composition. The intermediate metavolcanics within the map-area are restricted to the Handy Lake Volcanic Sequence. The intermediate metavolcanics weather typically light grey, greenish grey, light green, and rarely buff-brown; fresh surfaces are generally shaded darker than the weathered surfaces and are grey, dark grey, and moderate to dark grey-green. Greenish weathering surfaces are more prevalent in rocks of low (greenschist) metamorphic rank; in higher (amphibolite) metamorphic ranks, the rocks weather grey in colour. Pyroclastic rocks including tuff, lapilli-tuff, and tuff-breccia are the most common volcanic rocks of intermediate composition but massive and porphyritic flows are also present.

MINERALOGY

Within the Houghton-Hough Lakes area, the intermediate metavolcanics have been metamorphosed to greenschist facies which is prevalent in the northern part of the map-area, and to the amphibolite facies which is prevalent in the southern half of the map-area. Metamorphic plagioclase, quartz, and biotite form the most consistent mineralogy in these rocks although, in the greenschist facies, rare primary plagioclase exists. In the greenschist facies the mineral assemblage, in order of importance, is typically plagioclase (albite-oligoclase) + quartz + biotite ± epidote ± chlorite ± carbonate (calcite, locally dolomite) ± opaque minerals (mainly pyrite, pyrrhotite) ± rare apatite. Mineral assemblages in the amphibolite facies metamorphic rank consist of plagioclase (oligoclase, andesine) + quartz + biotite ± muscovite ± retrograde chlorite ± hornblende ± epidote ± carbonate ± garnet ± apatite ± staurolite ± andalusite ± sillimanite ± sphene ± rare zircon ± rare tourmaline. Foliation is generally prominent in the rocks of greenschist facies rank whereas, in the amphibolite facies, the rocks generally appear massive to weakly foliated in the field.

Plagioclase is the dominant constituent of the intermediate metavolcanics and appears as several forms depending on metamorphic rank. In the lowest greenschist metamorphic rank it locally retains its original composition with euhedral, lath-shape crystals forming randomly oriented phenocrysts or crystal tuff fragments up to 4 mm (average 2 mm) that are readily visible in the field. Thin section indicates these plagioclase crystals exhibit complex twinning including a composite of pericline, Carlsbad, and albite twins and are commonly altered to sericite to varying degrees. More commonly, in the greenschist facies, the plagioclase is partially to completely recrystallized and forms anhedral, mostly twinned, subgrains of albite-oligoclase that are sericitically altered to varying degrees. This recrystallized plagioclase varies from less than 0.1 mm to 2.0 mm and this range in size can generally be seen in a single thin section. Plagioclase subgrains are commonly intermixed with quartz subgrains of similar dimensions and except for the sericitic alteration of the plagioclase, the two are hard to distinguish. In intermediate metavolcanics metamorphosed to the amphibolite facies, plagioclase is almost invariably completely recrystallized and is present along with quartz of similar habit; the two are indistinguishable and form a granoblastic texture (Spry 1969). Grain size of this granular mosaic is not as diverse in the amphibolite facies as compared to greenschist facies plagioclase and averages 0.1 to 0.3 mm. Porphyroblastic plagioclase forms subhedral laths (1.0 to 2.0 mm) that are visible in the field and appear similar to phenocrysts; it also forms smaller porphyroblasts (0.7 mm) that are not evident in the field. Some of the coarser plagioclase crystals are recrystallized around the margins whereas the core is unrecrystallized, altered to sericite and these appear to be possible phenocrysts. For the most part the plagioclase of amphibolite facies rank is not heavily altered to sericite but is fresh and appears indistinct from quartz. In one locality in the mixed volcanic unit 1.6 km northwest of Island Lake, poikiloblastic plagioclase forms a helicitic structure (Spry 1969, p.169).

Quartz is the second most prominent constituent and is present as recrystallized, anhedral grains in both the greenschist and amphibolite facies. Rare, euhedral quartz phenocrysts or crystal fragments are also generally recrystallized forming slightly coarser subgrains than normal but the original euhedral form is preserved.

Biotite is the most common mafic mineral. In the greenschist facies it predominates as individual, aligned to subaligned crystals (average 0.3 mm) but is locally present less commonly as crystal aggregates that form clots (3 to 4 mm). The clots are subaligned to the foliation imparted to the rock by the alignment of the individual biotite crystals. Chlorite, carbonate, epidote, opaque and accessory minerals are commonly associated with the mafic clots. These clots are most prevalent in intermediate metavolcanics metamorphosed to medium-grade (amphibolite) conditions found mainly in the southern part of the map-area. Both the individual biotite flakes and crystal aggregates are visible in the field. In the amphibolite facies the biotite flakes are generally not as large and the width to length ratio of the flakes tends to be smaller. Due to the smaller size of the biotite flakes, their presence in a granoblastic mixture of quartz and feldspar, and the fact that the biotite flakes are subaligned to locally randomly oriented, the intermediate metavolcanics of amphibolite facies metamorphic rank appear less markedly foliated in the field.

Chlorite (prochlorite) is present as fan-shaped crystal aggregates in greenschist facies rocks associated with the biotite clots described above. Chlorite is commonly partly metamorphically prograded to biotite. Prochlorite is also found as a hydrothermal product invariably associated with secondary quartz veinlets and also deposited along fracture zones. In the amphibolite facies penninite and less commonly prochlorite are almost invariably intergrown with biotite and are products of retrograde metamorphism. Retrograde chlorite is abundantly developed throughout the intermediate metavolcanics of amphibolite facies in the southeastern part of the map-area.

Hornblende varies in abundance from 0 to 20 percent but generally forms less than 8 percent by volume of the intermediate metavolcanics. The hornblende has green-blue birefringence and occurs as poikiloblasts in rocks of amphibolite facies metamorphic rank. The poikiloblasts are subhedral and range in size from 0.7 to 2.0 mm.

Muscovite forms 0 to 10 percent of these rocks in the form of individual flakes (0.7 mm) associated in places with biotite.

Epidote and carbonate are present as alteration products of plagioclase in intermediate metavolcanics of the greenschist facies. Epidote forms 0 to 3 percent of these rocks and occurs as individual subhedral crystals and crystal aggregates. Carbonate, mostly in the form of calcite and minor dolomite, forms as an alteration product of plagioclase but is also present as crosscutting veinlets. In the vicinity of Hough Lake, the intermediate metavolcanics commonly contain an anomalously high (5 to 6 percent) carbonate content much of which is secondary.

Garnet, apatite, staurolite, andalusite, sillimanite, sphene, minor zircon, and minor tourmaline are common accessory minerals in amphibolite facies rocks. The garnet staurolite-muscovite schist (Code 2t, map, back pocket) on the east shore at Exploration Lake is the most extensive of these occurrences. Here staurolite forms about 20 to 25 percent of the rock. The megacrysts of staurolite average 2.0 cm in length and commonly display cruciform twinning, a typical habit of the mineral. In most occurrences the other aluminum silicate minerals are fine-grained, and concentrations averaging only 1 or 2 percent make their identification in the field difficult. Pyrite and pyrrhotite are common accessories (generally 1 percent) in all metamorphic grades of the intermediate metavolcanics.

MASSIVE AND PORPHYRITIC FLOWS

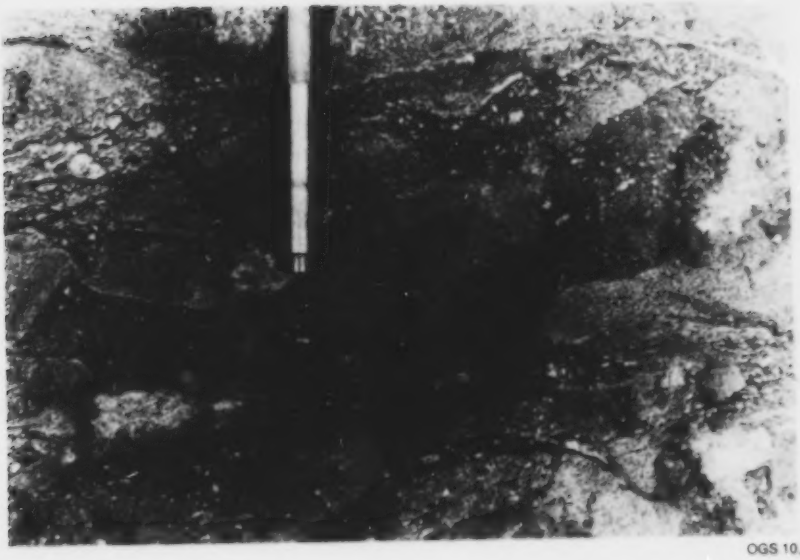
Intermediate flows compose only a minor percentage of the intermediate metavolcanic sequence and are found on several islands in the vicinity of the north shore of Hough Lake and in the southeastern part of the map-area. Porphyritic (plagioclase) flows are more abundant than the massive flows. Plagioclase phenocrysts range from 2 to 4 mm and are distinctly visible in the field as white-weathering laths. Except for a single exposure of flow breccia, flow contacts were not observed. The porphyritic flow near the north shore of Hough Lake is not continuously exposed but is at least 30 m thick and probably 2.0 km in length. The composition of the plagioclase phenocrysts is original and is andesine. The phenocryst population forms approximately 15 percent of the rock; about half of the phenocrysts are fractured and occur as broken, subhedral crystals. Matrix plagioclase is not visible in the field; in thin section, the plagioclase in the matrix is recrystallized to anhedral granules. In the southeastern part of the map-area, massive and porphyritic flows are complexly interlayered with intermediate and felsic pyroclastic rocks. The flows in this area are metamorphosed to the amphibolite metamorphic facies; many of the porphyritic-appearing phenocrysts may, in fact, be porphyroblasts and are indicated by map code 2p (Geological Map, back pocket). Thin section examination shows the coarse plagioclase crystals to be predominantly phenocrysts; the margins of the phenocrysts are recrystallized and tend to blend into the matrix. The interior of the phenocrysts are untwinned but commonly display a sieve-like texture composed of tiny granules of a presumably recrystallized plagioclase feldspar. Locally, a few inclusions of biotite are present in the phenocrysts but these are uncommon. In the field, flow breccia (Photo 1) occurs rarely and did not give any indication of stratigraphic tops. Locally, the plagioclase phenocrysts are subaligned (Photo 2) into what may be a primary flow lineation. The plagioclase phenocrysts form, on the average, 5 to 10 percent by volume of the rock but locally, for example, in the area situated 0.8 km southwest of Exploration Lake, the plagioclase phenocryst population is scarce (2 percent). In this same area southwest of Exploration Lake, the porphyritic intermediate flows appear similar to and almost laterally continuous with porphyritic subvolcanic intrusive rocks south of Patterson Lake. These flows may be coeval, genetically related to the latter. The porphyritic flows are distinguished from the porphyritic intrusive rocks by the following:

(1) feldspar forms the sole phenocryst population in the flows whereas feldspar and quartz phenocrysts populate the intrusive rocks;

(2) the maximum size of the phenocrysts in the flows (2.0 mm) is generally smaller than the phenocrysts in the intrusive rocks (4.0 mm);

(3) the porphyritic flows are generally more foliated than the more massive porphyritic subvolcanic intrusive rocks.

The matrix of the porphyritic flows is similar to the massive flows; all primary textures have been obliterated and both types of flows are highly recrystallized to a granoblastic mosaic of quartz, plagioclase, and biotite. Massive flows of intermediate composition appear similar to fine pyroclastic tuffs of the same composition but are distinguished from the latter by their less fissile nature.



OGS 10,083

Photo 1–Intermediate flow breccia just west of the small secondary road loop west off Highway 599 in the southeast part of the map-area. The porphyritic flow, easily distinguished by the plagioclase phenocrysts and slightly darker weathering, is similar in composition to the massive, nonporphyritic, lighter weathering intermediate metavolcanic phase. The latter phase is highly recrystallized and may be either an intermediate tuff or flow. Length of pen shown is 11 cm.

PYROCLASTIC DEPOSITS

Pyroclastic rocks comprise the greater proportion of the intermediate metavolcanics and based on Fisher's (1966) classification include tuff (fragments less than 2 mm), lapilli-tuff (fragments from 2 to 64 mm), and tuff-breccia (fragments greater than 64 mm). Crystal tuff also forms an important constituent in the pyroclastic deposits and is locally found to comprise the matrix of the coarser pyroclastic accumulations described above. Tuff and lapilli-tuff are estimated to comprise 55 percent of the intermediate pyroclastic rocks; tuff-breccia is estimated to comprise 30 to 35 percent of these rocks whereas crystal tuff constitutes the remainder of the pyroclastic accumulation. Although the coarsest intermediate pyroclastic rocks are found in the northeastern part of the map-area and most of the intermediate pyroclastic rocks in the south are finer in grain size, no consistent size gradation of fragments was noted in the Houghton-Hough Lakes area. The coarser, intermediate pyroclastic rocks (lapilli-tuff and tuff-breccia) are classified into the intermediate category solely on the basis of mafic content of the matrix material.

OGS 10.084

Photo 2–Intermediate porphyritic flow showing cross alignment of plagioclase phenocrysts (approximately parallel to pencil) and amphibole porphyroblasts (approximately perpendicular to pencil). The alignment of the plagioclase is possibly primary, related to lava movement whereas the amphibole alignment is secondary, subparallel to the axis of the major fold. From exposure west of Highway 599 and just east of the axial trace of the major fold. Pencil is 3.3 cm in length.

Tuff and Lapilli-Tuff

Tuff and lapilli-tuff are found throughout the intermediate metavolcanic sequence. In the field these rocks are recognized by the presence of fragments of volcanic rocks; these fragments are generally distinct because they differ in composition from their matrix. Lapilli-size fragments are distinguishable in all metamorphic grades. Tuff-size fragments, readily distinguishable in rocks metamorphosed to the greenschist facies, are less distinct in the higher metamorphic grades. Near the intrusive complexes in the southern part of the map-area intermediate tuff is commonly indistinguishable from intermediate flow. Although all compositions of fragments are found within the intermediate, finer grained pyroclastic accumulations, fragments tend to be more felsic than their matrix. Locally, individual lapilli-tuff deposits characterized by unique composition and/or packing density of fragment population are evident. These individual lapilli-tuff deposits are laterally discontinuous over tens of metres and are not delimited at the present scale of mapping.

OGS 10,085

Photo 3–Intermediate tuff (lower part of photo), reworked tuff (middle), and lapilli-tuff (top) from east shore of Hough Lake. The reworked tuff is probably ash fall which accumulated during a pause in volcanic activity between two successive pyroclastic flow deposits. Note also that the bedding is cutting sharply across the regional foliation which is only vaguely depicted in the photograph. Pen is about 16 cm in length.

Lapilli-tuff fragments are commonly lensoidal having been tectonically deformed parallel to the regional foliation. In most cases the regional foliation and parallel elongation of the fragments is thought to reflect the overall trend of the intermediate metavolcanic formation but locally, for example, on the east shore of Hough Lake, the fragments were found to be tectonically orientated at a high angle to the direction of bedding (Photo 3). These areas of discordance which tend to be at a high angle to the regional trend are rare and represent either local slump features or minor folding adjustments.

Bedding is generally absent in these pyroclastic deposits but commonly tuff deposits grade imperceptibly, by increase in size of fragments, into predominantly lapilli-tuff units. Except for these areas of mixing, discrete tuff and lapilli-tuff units appear to be poorly sorted. The lack of well developed bedding or layering in most of these units plus, poor sorting, and the extent and thickness of the finer (tuff) deposits suggest many of these pyroclastic deposits may have originated as ash flows (Pettijohn *et al.* 1973, p.278).

Lapilli-tuff is also locally interbedded with metasediments in the northern part of Shoehorn Lake where it forms beds 15 cm to 1 m thick interlayered with iron formation, siltstone, and arkosic sandstone.

OGS 10.086

Photo 4–Poorly sorted, intermediate tuff-breccia from southwest shore of Shoehorn Lake. There are a variety of lithologies represented in the fragment population one of which in the top-right corner exhibits a zonal structure of unknown origin. The fragments are generally all subaligned parallel to the regional foliation. Many of the coarser fragments are subrounded to round. Pen is approximately 16 cm in length.

Except for the commonly sharp outline of fragments, primary textures are completely obliterated in all metamorphic grades. In thin section, fragments are distinguished from their matrix by differences in grain size (degree of recrystallization to some extent), mafic mineral content, and mineral associations.

Tuff-Breccia

The coarsest and most extensive intermediate pyroclastic rocks are found in the vicinity of the southern part of Shoehorn Lake (Photo 4) where the fragments attain a maximum dimension of approximately 45 cm. These coarse pyroclastic units are more massive than the finer pyroclastic rocks; the fragments also tend to be more subrounded to subangular and less commonly ellipsoidal. The rounded shape of the fragments may have originated in several ways depending upon the origin of the pyroclastic unit itself. These include the following:

(1) the rounded fragments may represent bomb ejecta thus the tuff-breccia is an agglomerate;

(2) the fragments may have been rounded by abrasion during flowage in a pyroclastic flow deposit; or
(3) some of the rounding may be secondary, related to the later folding deformation processes.

Probably all three of the above processes are applicable although, because of the massive nature of many of these coarse pyroclastic units, it is the author's opinion that the dominant forces acting to mould the fragments were primarily (1) or (2) above. Composition of the fragments varies in many units from intermediate to felsic although the former is more common than the latter. Mafic fragments are exceedingly rare within the intermediate tuff-breccia units but were noted near the east shore of the small inlet between Fairchild Lake and Moosolf Lake.

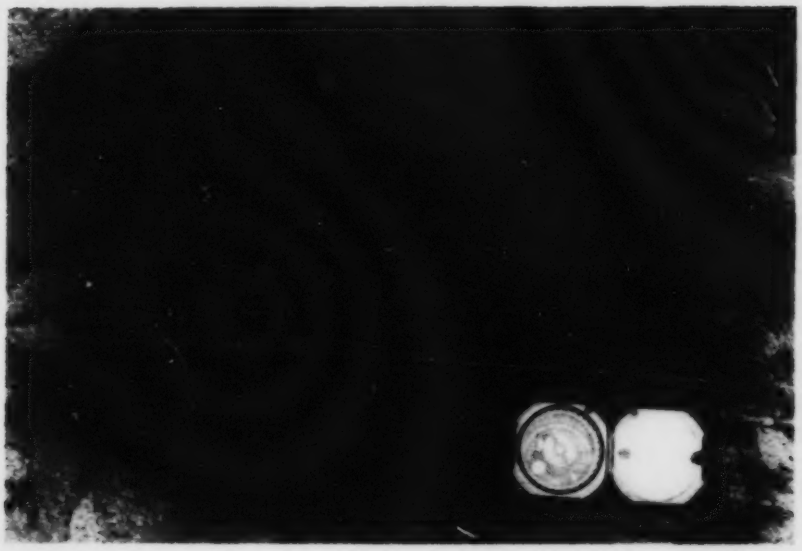
There is a wide variety of texture exhibited by the coarse fragments; the greater proportion of fragments contain euhedral to fractured, lath-shaped plagioclase crystals that are visible in the field and represent porphyritic intermediate and felsic flows and intermediate crystal tuff. The great variation in types of fragments present in many of the coarse pyroclastic units implies many are accidental representing country rock incorporated possibly during ash flowage.

One fragment (Photo 4) was observed to have a successive ring or zonal structure indicated by the presence of two dark rings, 3 to 4 mm in width. The origin of this ring structure may be due to either successive periods of weathering prior to accidental inclusion within the pyroclastic unit, or chemical alteration prior to consolidation.

Bedding was not observed in any of the intermediate tuff-breccia units. The fragments are generally uniformly distributed in a tuffaceous matrix which forms 40 to 50 percent by volume of the rock. Locally, in the vicinity of Shoehorn Lake within the space of single exposures (7.8 m across) there are areas devoid of large fragments leaving only patches of massive matrix ash (Photo 5). In tuff-breccia units composed of a wide variety of fragments the sorting is generally poor (see Photo 4) whereas those composed predominantly of one lithology tend to be better sorted (Photo 5). The coarse fragments are generally oriented subparallel to the regional foliation but locally the fragments are randomly oriented. Also, locally on Shoehorn Lake the matrix contains up to 5 percent whole and fragmented plagioclase crystals (Photo 5). Some of the coarser, unsorted pyroclastic units near the south end of Shoehorn Lake could have originated as volcanic lahars (Macdonald 1972, p.170).

Crystal Tuff

Intermediate crystal tuff forms an integral part of the intermediate pyroclastic sequence. It is characterized by the presence of predominantly feldspar (albite, oligoclase) crystal and crystal fragments along with a minor amount of quartz crystals; these two coarser crystal populations generally form approximately 4 to 5 percent by volume of the rock. Crystal tuff of intermediate composition is found in isolated lenses of limited extent and is easily confused with intermediate porphyritic flows; more commonly it constitutes the matrix of coarser lapilli-tuff and tuff-breccia (Photo 5) units and is easily recognized at the



OGS 10.087

Photo 5–Well sorted tuff-breccia with crystal (plagioclase) tuff matrix. The fragments are of a single lithology, fairly well rounded, and are not uniformly distributed leaving large patches of the crystal tuff matrix.

south end of Shoehorn Lake, west of the north end of Moosolf Lake, and on the south shore of Houghton Lake. In general, these latter rocks are massive and the crystal fragments are randomly oriented whereas in units consisting solely of crystal tuff, foliation is more prominent and the crystals themselves are subaligned. The presence of scarce quartz crystals helps to distinguish crystal tuffs from porphyritic flows of similar (intermediate) composition. Crystal tuff in which there are no obvious volcanic fragments is also similar in megascopic appearance to subvolcanic porphyritic (feldspar-quartz) intrusive rocks although the latter are characteristically more felsic, have a greater quartz crystal population, and are generally more massive.

BEDDED AND/OR REWORKED PYROCLASTIC ROCKS

Rocks classified as reworked pyroclastic rocks in the Houghton-Hough Lakes map-area fall into one of the two categories based on the classification of volcaniclastic rocks by F.J. Pettijohn *et al.* (1973). According to F.J. Pettijohn *et al.* (1973), volcaniclastic rocks are of two types, each related to the dominant force acting in their production and include (1) those of pyroclastic origin and (2)

those of erosional origin. The dominant force in those of pyroclastic origin is volcanic in that they originated as exploded (igneous derived) ejecta but were sorted in a medium of air or water and deposited as ash fall. These two processes essentially form a single deposit. The volcaniclastic rocks of erosional origin (type 2, above) differ in that they have actually been deposited during two separate periods by two distinct forces. That is, they have been previously deposited by volcanic means and subsequently reconstituted by erosional forces such as water and redeposited as volcaniclastic rocks that are more comparable to true metasediments. As such, they are expected to exhibit primary structures indicative of their last (sedimentary) depositional history such as scouring, crossbedding, or presence of sharp, erosional basal contacts exhibited by individual bedded units.

In the Houghton-Hough Lakes area both types of volcaniclastic rocks are present to a minor extent. Those believed to be largely of volcanic origin have been included within the intermediate metavolcanics as "bedded tuff". Volcaniclastic rocks interpreted by the author to be largely due to erosional or sedimentary forces are included within the metasediments as "tuffaceous metasediments". In the field "bedded tuff" is distinguished from "tuffaceous metasediments" by the criteria given in Table 3.

Bedded and/or reworked tuff deposits are local in extent and most commonly found between Shoehorn and Fisher Lakes. The most extensive bedded tuff sequence was found 450 m south of Fisher Lake and is composed of intermediate tuff beds ranging from 0.8 cm to 3.8 cm in width. Although minor tuff and lapilli-tuff units interrupt the stratigraphy, these bedded tuffs form a sequence that is 60 to 90 m thick. Thin section examination indicates that volcanic fragments are fairly abundant and that feldspar fragments (0.4 to 0.6 mm) are three times more abundant than quartz fragments. Although there is a matrix it generally form less than 10 percent of the rock. In the field the bedding is distinguished by compositionally different, light grey and moderately dark green beds that are observed in thin section to be feldspathic-rich and chlorite-rich beds respectively.

Locally, a greywacke texture characterized by subangular lithic, feldspar, and quartz fragments (0.2 m) present in a matrix (0.05 mm or less), is observed but these differ from greywackes observed in the metasedimentary units in that lithic fragments are much more abundant.

Locally, tuff that is thought to be an ash-fall deposit marking a break in the major volcanic activity is found separating successive pyroclastic deposits (see Photo 3).

These reworked tuff deposits are all characterized by bedding planes that are diffuse and partially gradational in both directions (i.e. up and down sequence).

MIXED METAVOLCANIC UNIT

The mixed metavolcanic unit forms a stratigraphic marker horizon that varies in width from 450 to 900 m and is traceable in the Houghton-Hough Lakes area, Conant Township (Bond 1973a), in Boucher Township (Trowell 1977a,b)

TABLE 3 CRITERIA USED TO DISTINGUISH TYPES OF VOLCANICLASTIC ROCKS IN THE HOUGHTON-HOUGH LAKES AREA.

	BEDDED TUFFS (pyroclastic origin)	TUFFACEOUS METASEDIMENTS (epiclastic origin)
1.	Contacts between individual beds are gradational, poorly defined. Beds are laterally uniform in thickness.	Contacts between individual beds are sharply defined. Beds are laterally uniform in thickness and locally discontinuous.
2.	Fragments are angular.	Fragments in matrix are subangular to subrounded, locally rounded, lensoidal.
3.	Fragments are fairly well sorted; grain size remains fairly uniform across sequence.	Fragments are poorly sorted with rapid changes in grain size from bed to bed.
4.	Bedding diffusely marked mainly by changes in grain size. Some show slight change in composition.	Bedding marked mainly by changes in grain size, and commonly by changes in composition.
5.	Vertical grading is indistinct but may be graded towards the top and bottom of single beds.	Vertical grading is commonly prominent, grading invariably towards the top of beds.
6.	No current structures such as cross-bedding or scouring are present.	Rare bedding plane markings such as scouring are present.
7.	No inclusions of underlying beds are present.	Inclusions of underlying finer beds are present in coarser, higher energy, overlying beds.
8.	Deposits of this type are commonly associated in a sequence of other volcanic rocks formed by volcanic processes.	Deposits of this type are commonly associated with and interlayered with well formed metasediments.

and in the Northeast Arm of Sturgeon Lake (Trowell 1975) for a strike-length of approximately 29 km. In the Houghton-Hough Lakes area it splits and forms two horizons within the Handy Lake Volcanic Sequence that coalesce at Evans Lake. The pattern of the two horizons of the mixed volcanic unit in the map-area is the result of either minor folding about a curvalinear fold axis between Exploration Lake and Evans Lake or due to interfingering of the volcanic formations. The mixed volcanic unit, best exposed on Highway 599 in the southeastern part of the map-area, is composed of predominantly intermediate pyroclastic rocks, minor amounts of intercalated metasediments, some intermediate volcanic flows, and rare hyaloclastic breccia; these lithologies are all characteristi-

OGS 10.088

Photo 6–Intermediate tuff-breccia with sparse felsic fragments in mixed metavolcanic unit. Diffuse mafic segregations are present in the tuff-breccia unit; a few of the mafic zones appear as possible fragments similar to that in the centre of the photo. Felsic fragments within tuff-breccia in the mixed volcanic unit are nearly always angular and are (commonly spatially) associated with the mafic component. Note the mafic component is not displaced by the felsic fragment and may have been formed after the emplacement of the felsic fragment in the tuff-breccia. Pen is about 16 cm in length. From southeastern part of the map-area on west side of Highway 599.

cally mixed with widely variable amounts of mafic amphibolitized volcanic zones. The proportion of the mafic metavolcanic component present varies from approximately 3 to 80 percent by volume of the exposed rock but, in general, is the lesser constituent. Due to the greater abundance of metavolcanics and tuffaceous metasediments of intermediate composition this unit is coded under the intermediate metavolcanic map code (see Geological Map, back pocket).

In the field, the intermediate and mafic components weather distinctly from each other: the intermediate metavolcanics weather grey to grey-brown and are dark grey on the fresh surface whereas the mafic metavolcanic component in contrast is distinctly dark green. Much of the intermediate part of the mixed metavolcanic unit especially in the extreme southeastern part of the map-area is composed of massive and less commonly porphyritic flows. Primary textures, including felsic fragments (Photo 6) and sedimentary bedding planes, are locally preserved and indicate the presence of several lithologies of different origins. However, if these primary textures were more widespread, they are no longer discernible due to the intense degree of recrystallization shown by many of these

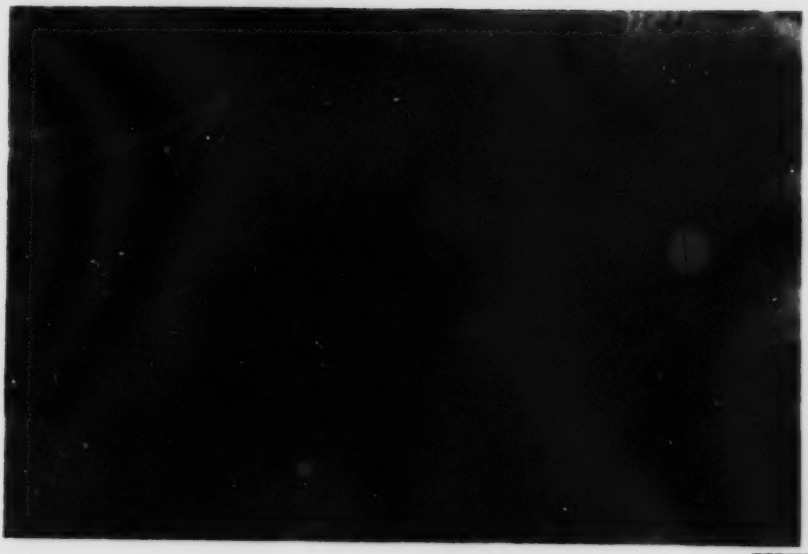


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Photo 7–Tuffaceous metasediments in mixed volcanic unit from the southeastern part of the map-area. Mafic layers that are concordant to the bedding may either represent mafic tuff deposits or may be secondary with the darkening of the adjacent tuffaceous metasediments being caused by metasomatism. Note numerous minor cross faults trending toward the top left corner of the photograph. Pen is approximately 16 cm in length.

rocks. Breccia-sized felsic fragments (Photo 6) are most prominent where present but finer fragments are generally not evident. The mixed volcanic unit is locally unsubdivided in areas lacking diagnostic classification features. W.R. Bulmer (1976) studied in detail the area around Evans Lake and found the mixed volcanic unit to be composed of tuff (ash to lapilli), tuffaceous metasediments (Photo 7), and minor amounts of hyaloclastic breccia. The hyaloclastic breccia, exposed on the west side of Highway 599 in the extreme southeastern part of the mixed volcanic unit just west of Evans Lake, is composed of mafic cuspate fragments visible in the field that are situated in a matrix of intermediate tuff or sediment. According to Bulmer (1976, p.27-28), in thin section the mafic fragments are composed of large poikiloblastic blades of biotite, cummingtonite, staurolite and magnetite. The hyaloclastic zone is discontinuous over 150 m. The metasediments, are commonly garnetiferous; in some, the bedding planes have been obliterated by metamorphic recrystallization and these areas are easily confused with intermediate flow or tuff. Bulmer (1976, p.16) distinguished the intermediate volcanic rocks from the sedimentary rocks by the former's "overall inhomogeneity, whispyness, medium-grained to fine-grained texture and grey colour although the distinction was often hazy".

The mafic zones are comprised of loosely aggregate to tightly concentrated amphibole crystals that form small equigranular clots, elongated lenses, and discontinuous bands that locally coalesce to form massive zones of amphibolite. In relation to the intermediate metavolcanic part the mafic metavolcanic component almost always weathers high. Based on field relations, the mafic volcanic component occurs in several different forms which, due to the present scale of mapping, are not distinguished on the map. In order of decreasing prominence these include the following.

(1) Linear Members — This is the most common form exhibited by the mafic volcanic component in the mixed volcanic unit. The mafic volcanic linear members include lenses and, locally, bands averaging 2.54 to 20.32 cm in width that are discontinuous over lengths varying from several centimetres to tens of metres. These linear structures are nearly always concordant to the overall trend of the mixed volcanic unit at that particular locality. In some areas the mafic lenses and bands are regularly spaced in intermediate volcanics and the rock appears to be banded although some of these bands actually coalesce across the trend of the mixed volcanic unit and appear to be discordant. Some of the mafic volcanic components coalesce to form massive zones greater than 10 square meters. In some of these massive mafic volcanic zones there are rare zones of intermediate volcanic host rock that may represent inclusions. In the southeastern part of the map-area these linear mafic members are commonly contorted about east-northeast-trending axes and represent minor folds related to the major anticlinal fold axes. Although not that apparent, Bulmer (1976) found some correlation between shape of the mafic component and its position in the structure of the map-area and that both folding and faulting, in part, influenced the shapes of the mafic clots. He found that lenses and boudinaged but unseparated knots or lenses are in areas of mild deformation whereas the less linear, separated mafic knots are found in areas of extreme deformation (Bulmer 1976, p.57). The folded mafic members are lineated; this lineation is partly expressed by the alignment of amphibole along their margins. The contact between the mafic volcanic member and its intermediate volcanic host varies from generally relatively sharp to less commonly diffuse over approximately 5 mm. No evidence of chilling or complementary change in apparent composition near the contact of the two components was evident in the field.

(2) Diffuse Mafic Clots — The mafic volcanic component is also present as loosely aggregated hornblende porphyroblasts (0.17 to 0.34 mm) that form diffuse clots (Photo 8) that average 1 to 20 cm in length and correspondingly 1 to 5 cm in width. The amphibole porphyroblasts form 30 to 40 percent by volume of the clots with the remainder simply being host intermediate metavolcanics. Obviously, because of the loosely concentrated nature of the amphibole the margins of these clots are diffuse and rather indistinct. These diffuse clots are generally less linear in form than the linear mafic members but do tend to be vaguely concordant to the strike of the mixed volcanic unit.

(3) Mafic Fracture Filling — This type occurs predominantly in the southeastern part of the map-area. In this, the mafic volcanic component is associated with quartz-filled fractures (Photo 9) that are generally discordant to the trend of the mixed volcanic unit. Commonly, the first type (linear) of mafic member discussed above is cut by these quartz-filled fracture zones. The fracture zones themselves do not form a pattern and instead many are found to crosscut one

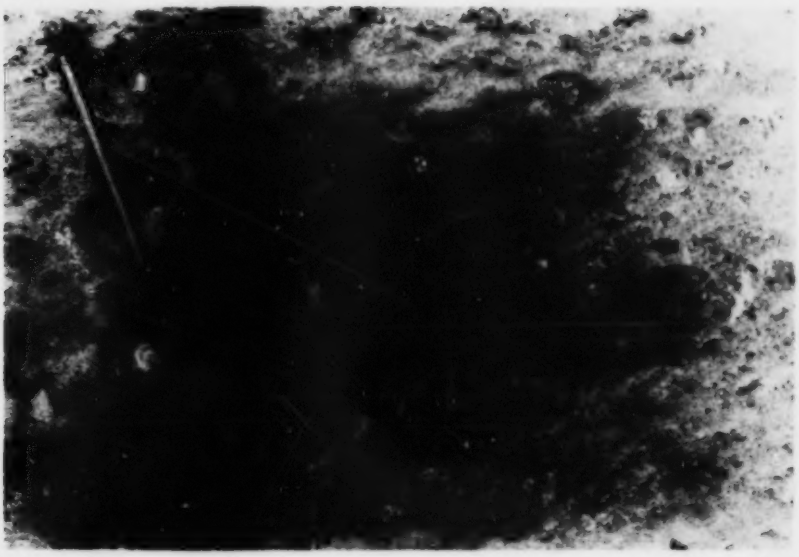

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Photo 8–Diffuse and massive mafic clots in intermediate volcanic mixed unit from southeastern part of the map-area west of Highway 599. The amphibole is loosely concentrated into aggregates that appear to be segregations although there is never any complementary leucocratic depletion halos associated. Pencil is approximately 18 cm in length.

another. The quartz veins vary in length from 5 cm to more than 15 m and average 0.63 to 1.26 cm wide. The mafic volcanic component associated with the quartz veining is generally medium to coarse grained; commonly, the part nearest the quartz vein is richer in amphibole than the part farthest away which is correspondingly richer in feldspar. The margin at the quartz vein is sharp; the margin between the mafic component (associated with the quartz vein) and the host intermediate volcanic part is diffuse. The close spatial association of the mafic component to the quartz-filled fractures suggests the former is in part metasomatic in origin. The lateral segregation of the mafic minerals is probably metamorphic in origin.

The northwestern extension of the mixed volcanic unit (i.e. that part west of Island Lake) is characterized solely by this type of structure in which the amphibole-rich constituent shows a definite affinity for the quartz veins. There the quartz veins are thin (2 to 4 mm), are discontinuous over 1 to 2 m, and generally are concordant to the stratigraphy. The quartz veins weather positively, are slightly greenish in colour due to the association of chlorite to the quartz, and locally, where lensoidal, appear almost like fragments. Sulphide mineralization including pyrite and chalcopyrite is locally associated with the quartz veinlets. None of the other structures described heretofore are present in this area and the author is not sure if this part actually is a continuation of the mixed volcanic

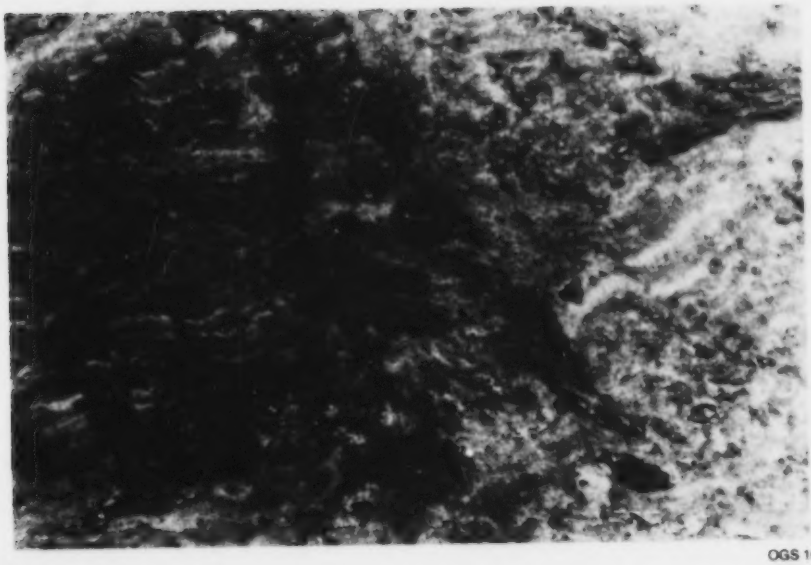

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Photo 9–Mixed metavolcanic unit showing association of mafic clots to hydrothermal quartz-veining from west side of Highway 599 in the southeastern part of the map-area. Vague more leucocratic zones trending east-west across the photo may be highly recrystallized, partly remobilized fragments. Lens cap is approximately 7.6 cm in diameter.

unit or whether it simply represents a zone of intense hydrothermal alteration.

(4) Bedded Mafic Members — Interbedded with some of the metasediments are massive amphibolite units up to 0.3 to 0.6 m in width that may represent recrystallized mafic tuff horizons (see Photo 7). These are generally extensively amphibolitized and fairly uniform in composition. Late stage minor transverse faults causing displacements of 0.6 to 1.2 m (2 to 4 feet) have commonly offset these mafic tuff horizons and their associated metasediments (see Photo 7).

(5) Mafic Fragments — Rarely the mafic clots form discrete, sharply defined, lensoidal structures that may actually represent mafic fragments (see Photo 6) although it is the author's opinion that the mafic clots do not, in general, represent pyroclastic fragments.

(6) Diatreme Structure — At two localities a diatreme-like structure was observed in which felsic fragments, that appear to be simply broken apart but still related to one another by mutually angular sides, are situated in the mafic volcanic component. The area covered by these diatreme-like structures averages about 8.3^2 metres.

(7) Inclusion Structure — Locally, along the margin of the large felsic volcanic mass situated just north of the mixed volcanic unit approximately 0.8 km north of Evans Lake, there are mafic volcanic lenses associated with the felsic volcanics. The mafic lenses are broadly concordant to the stratigraphy but are

TABLE 4 EVIDENCE FOR AND AGAINST POSSIBLE ORIGINS OF THE MIXED VOLCANIC UNIT IN THE HOUGHTON-HOUGH LAKES AREA.

	Origin/Documented Elsewhere		Supporting Evidence	Evidence Against
PRIMARY ORIGINS	1. Primary mixing of two contrasting magmas (Eichelberger 1975; Wiebe 1974; MacDonald and Katsura 1965)	a. Mixing prior to extrusion (i.e. magma - magma mixing)	- extensive area over which mixing took place - lack of chilled margins in either phase	- availability and maintenance of two contemporaneous magmas unlikely
		b. Mixing occurs after extrusion (i.e. lava-prevolcanic rock mixing)	- diatreme structures - local inclusions of mafic volcanic phase in felsic volcanics	- lack of incorporation of variety of lithologies and not just mafic varieties - extensive mixing rather than restriction to contact zone
	2. Fractional melting from a single magma source (Yoder 1973)			- no gradational compositions between two end phases apparent in the field - contacts between phases relatively sharp
	3. Immiscible splitting of single parent magma (Drever 1960; Gelinas *et al.* 1976)			- lack of uniformity in texture or structure of two phases - lack of uniform distribution of two phases
	4. Pyroclastic - two different source areas supplying material to the same area		- concordant mafic bands in different lithologies including intermediate and felsic volcanics and metasediments - discrete lenticular bomb-like structures of mafic volcanic phase	- does not explain all types of structures in the mixed volcanic unit
	5. Intrusion of magma into semi-consolidated and unconsolidated fluidal sediments (Snyder and Fraser 1963)		- interlayered mafic volcanic clots and lenses in metasediments	

Table 4 continued

	Origin/Documented Elsewhere	Supporting Evidence	Evidence Against
SECONDARY ORIGINS	6. Metamorphic differentiation	- diffuse structure - orientation of many of the mafic clots parallel to the trend of the mixed unit possibly related to regional metamorphic event - mafic clots not displaced by felsic fragments in pyroclastic units - local leucocratic mineral concentrations in mafic phase	- absence of depletion halos in intermediate volcanic host adjacent to mafic phases - haphazard distribution and variety of mafic structures
	7. Hydrothermal	- association of mafic phase to quartz-filled fractures - in northwest extremity, association of sulphide minerals to quartz veinlets with amphibole concentrated along the margins	- possible that the quartz developed after the formation of the mafic phase and represents an initial partial melt of the latter

locally offset by minor transverse displacements. These mafic lenses average 0.3 to 0.6 m in width and are discontinuous over distances of 3 to 5 m.

In thin section the intermediate volcanic part of the mixed volcanic unit consists of plagioclase (oligoclase?) + quartz + biotite + muscovite ± retrograde chlorite ± epidote ± tourmaline ± sphene. Generally, the rock is highly recrystallized as evidenced by a well developed granoblastic texture in thin section. Locally volcanic fragments are preserved in thin section but these are rare. Felsic fragments (see Photo 6) are composed of a finely recrystallized (0.1 mm) granoblastic mosaic of mostly quartz and plagioclase, 5 to 8 percent poikiloblastic amphibole, and minor (2 percent) biotite. Some of the amphibole in the southeast is distinctly blue-green and may be sodic amphibole. The amphibole is nearly always poikiloblastic with granular quartz-plagioclase inclusions; it forms euhedral to subhedral, randomly oriented prismatic crystals (0.5 to 2.0 mm in length) that appear to postdate the regional metamorphism. In one thin section the regional (biotite) foliation was observed to wrap around a poikiloblastic amphibole implying that the amphibole predated the regional metamorphism but this relation is so rare that it cannot be taken as meaningful. The chlorite is always present as a product of retrograde metamorphism.

The mafic part of the mixed metavolcanic unit is composed predominantly of amphibole and quartz; lesser proportions of recrystallized plagioclase, biotite, and minor epidote are also present. The amphibole is mainly hornblende which forms coarse, stubby, commonly poikiloblastic, randomly oriented crystals which postdate the regional metamorphic foliation. Commonly the amphibole is anhedral but subhedral prismatic forms (0.5 to 2.0 mm) are locally present; the amphibole tends to be concentrated into clusters. Most of the hornblende is dark green and strongly pleochroic but near Evans Lake the amphibole has a distinct blue-green birefringence indicative of the more sodic varieties. Minor actinolite occurs along with abundant chlorite in the northwestern extension of the mixed volcanic unit. Amphibole percentage varies widely such that some of the mafic portions are almost completely amphibolitized. Most commonly the grain size is medium to coarse grained (2 to 3 mm). Plagioclase is more finely recrystallized and is commonly found towards the margins of the clots where it blends into and is camouflaged by the matrix. Quartz is generally concentrated in the centre of the clots and is for the most part undoubtedly secondary. Garnets (3 to 5 mm) are common in the more extensively amphibolitized parts and locally form 10 percent of the rock. Bulmer (1976, p.18) found some of the garnetiferous amphibolitic zones to contain bands of alternating, fine laminations of quartz and amphibole. Chemical analyses of these garnetiferous horizons by Bulmer (1976) indicate that sufficient iron is present to suggest that these zones may be metamorphically derived equivalents of iron formations, a relation also noted by E.G. Pye (1957). Bulmer (1976, p.59) found that the core of the mafic portions are commonly composed of epidote. He also reports (1976, p.58) individual mafic blobs from east of Highway 599 with "mafic hornblende rims with epidote/diopside centres".

Chemical analyses of representative samples of the mixed volcanic unit taken from Bulmer (1976) are given in Table 5, Numbers 32, 33, 34, and 35. These samples are located in Figure 4 (Chart A, back pocket) and plotted on both the AFM plot (Figure 3) and the Jensen Cation Plot (Figure 2). Samples 32 and 34 are slightly more mafic in composition according to T.N. Irvine and

W.R.A. Baragar's (1971) classification in comparison to L.S. Jensen's classification and this may be due to carbonate alteration giving an above average normative plagioclase composition. According to Jensen's (1976) classification the matrix of the mixed volcanic unit is predominantly calc-alkaline andesite in composition. Sample 34 plots in the tholeiitic dacite field, but it is a borderline plot lying close to the calc-alkaline andesite field. Its displacement in the tholeiitic dacite field is regarded to be within the limits of experimental error. Sample 35, taken from a mafic clot indicates the mafic portion of the mixed volcanic unit is calc-alkaline basalt.

Based on field relationships observed in the Houghton-Hough Lakes area, several possible origins with supportive and contradictory evidence for the mixed volcanic unit are presented in Table 4. Due to the fact that the mafic phase forms a variety of structures, is volumetrically haphazardly distributed, and is found in a variety of lithologies that are generally of intermediate composition, it is the author's opinion that several origins including the mixing of two different magmas, pyroclastic, metamorphic segregation, and hydrothermal activity were involved in the formation of the mixed volcanic unit. Of these origins, the mixing of two magmas prior to extrusion from a single source area and the pyroclastic origin, are the most plausible in that they both explain why the mixing was so complete over such an extensive area. For a pyroclastic origin there would have to be two source areas: one possibly in the Savant Lake area and one in the Sturgeon Lake area. The fact that the mixing occurred between intermediate and mafic volcanic rocks is not surprising when one considers that the mixed volcanic unit is interposed between a dominantly mafic sequence exposed in the Northeast Arm of the Sturgeon Lake Greenstone Belt and a dominantly intermediate to felsic sequence in the Houghton-Hough Lakes area in the Savant Lake Greenstone Belt. In all likelihood these phases were partially modified by the secondary processes (hydrothermal and metamorphic segregation) and a combination of all the mechanisms referred to above was active in the production of the mixed volcanic unit.

UNSUBDIVIDED INTERMEDIATE METAVOLCANICS

Intermediate metavolcanics situated within the southeastern part of the map-area have been metamorphosed to medium to locally high-grade conditions and are for the most part unsubdivided on the map due to lack of primary textures. Lapilli- and breccia-sized felsic fragments were the only primary texture observed. Megascopically the unsubdivided intermediate metavolcanics are aphanitic to fine grained and massive to weakly foliated; in thin section these rocks commonly exhibit a granoblastic-polygonal texture (Spry 1969, p.186). These rocks are mineralogically uniform consisting predominantly of plagioclase + quartz + biotite ± muscovite ± garnet. Garnet is most abundant in the area along the south-central boundary of the map-area, between Houghton Creek and the small lake 4 km west of Evans Lake. Except for the muscovite and lower modal biotite content, the mineralogy of these intermediate metavolcanics is comparable with highly recrystallized metasediments of the English River Subprovince; it is possible that some of the rocks are in fact of metasedimentary ori-

TABLE 5 | CHEMICAL ANALYSES OF VOLCANIC AND INTRUSIVE ROCKS IN THE HOUGHTON-HOUGH LAKES AREA

Sample	1	2	5	6	8	9	10	11	12	13	14	15	16
SiO_2	49.8	54.6	59.2	63.4	55.6	62.3	73.2	75.6	75.5	75.3	75.4	72.5	70.9
Al_2O_3	16.1	17.8	15.4	14.8	17.6	16.0	13.5	13.8	14.3	12.4	12.9	14.4	14.3
Fe_2O_3	.38	1.32	1.87	1.90	7.52	5.86	.67	.74	.28	.55	1.35	3.40	3.27
FeO	9.65	4.87	2.68	3.74	.00	.00	1.87	.81	.41	1.62	.00	.00	.00
MgO	5.40	3.10	1.86	3.73	4.16	.74	.98	.41	.21	.48	.26	.69	.42
CaO	10.4	6.63	7.44	3.80	8.60	3.87	1.87	.97	.65	.75	.54	1.60	1.80
Na_2O	1.89	3.50	3.72	3.91	1.91	3.67	3.34	3.37	4.33	3.21	4.13	1.75	4.70
K_2O	.19	1.83	1.23	1.59	1.88	2.60	2.36	2.51	2.43	2.58	3.11	3.21	1.88
TiO_2	.70	.60	.41	.68	1.01	.46	.28	.09	.22	.19	.25	.50	.43
P_2O_5	.05	.31	.12	.15	.00	.00	.05	.02	.01	.05	.00	.00	.00
S	.02	.05	.01	.01	.00	.00	.01	.03	.01	.02	.00	.00	.00
MnO	.26	.12	.13	.12	.00	.00	.07	.04	.02	.05	.00	.00	.00
CO_2	2.34	3.96	4.56	.19	.00	.00	.29	.15	.14	.18	.00	.00	.00
H_2O^+	1.23	1.01	.71	1.08	1.72	4.51	.83	.96	.75	.83	2.09	1.95	2.30
H_2O^-	.06	.05	.18	.21	.00	.00	.06	.09	.00	.07	.00	.00	.00
TOTAL	98.46	99.75	99.52	99.31	100.00	100.00	99.38	99.59	99.26	98.28	100.03	100.00	100.00
Specific Gravity	2.93	2.79	2.72	2.78	ND	ND	2.65	2.69	2.61	2.68			
Normative Plagioclase Composition	An_{67}	An_{47}	An_{39}	An_{34}	An_{66}	An_{37}	An_{23}	An_{13}	An_8	An_{11}	An_7	An_{34}	An_{17}
Color index	39.4	18.9	17	17.3	23.7	8.7	6.1	2.7	1.3	4.2	1.7	4.9	3.9
TRACES (PPM)													
Ag	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1		< 1
Ba	70	490	400	140	150	1030	340	290	400	440	340		280
Be	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1					
Co	55	25	20	20	25	10	7	5	< 5	< 5	< 5		< 5
Cr	360	40	100	35	40	45	25	5	6	6	< 5		< 5
Cu	120	65	80	70	60	9	6	10	< 5	7	< 5		< 5
Ga	20	20	10	10	20	20	20	20	20	10	< 10		20
Li	8	30	10	7	10	8	8	6	6	15	6		10
Mn					1000	3280					120		230
Mo	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10		< 10
Ni	160	70	70	30	70	35	15	5	< 5	< 5	< 5		< 5
Pb	< 10	85	30	< 10	< 10	< 10	< 10	< 10	< 10	35	< 10		< 10
Sc	50	30	30	10	30	< 10	< 10	< 10	< 10	< 10	< 10		< 10
Sn	1	1	1	1	1	< 1	1	< 1	< 1	< 1	< 1		< 1
Sr	200	800	500	300	300	300	300	70	100	100	100		100
V	200	200	100	100	300	90	80	70	70	70	60		70
Y	< 10	< 10	< 10	20	< 10	< 10	20	20	20	20	30		20
Zn	110	400	160	80	80	90	75	100	40	65	30		60
Zr	20	200	200	300	20	200	500	400	700	500	400		600
Ti													
MOLECULAR NORMS													
ap	.11	.68	.27	.32	.00	.00	.11	.04	.02	.11	.00	.00	.00
po	.07	.18	.04	.04	.00	.00	.04	.10	.04	.07	.00	.00	.00
il	1.04	.88	.61	.97	1.45	.88	.40	.13	.31	.28	.00	.73	.62
or	1.20	11.41	7.77	9.63	11.51	16.34	14.43	15.31	14.69	16.09	18.95	19.97	11.48
ab	18.13	33.13	35.68	35.96	17.75	35.03	30.99	31.21	39.74	30.21	38.22	16.53	43.55
an	37.28	28.95	23.18	18.31	35.10	20.40	9.25	4.83	3.23	3.56	2.76	8.35	9.22
cor	.00	.00	.00	.11	.00	.13	2.45	4.30	3.78	3.53	1.98	5.90	1.42
mag	.42	1.45	2.08	2.04	2.72	2.18	0.72	.82	.00	.00	.00	.00	.00
hem	.00	.00	.00	.00	.00	.00	.00	.00	.30	.60	.00	1.98	1.97
wo	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.97	.15	.08
en	12.32	8.17	1.30	10.55	9.16	2.17	2.80	1.17	.00	.00	.00	.00	.00
fs	11.61	5.52	.62	3.77	3.06	3.63	2.19	.59	.59	1.38	.74	2.00	1.20
q	3.80	6.72	16.10	19.73	11.97	19.44	36.63	41.50	.13	1.96	.00	.00	.00
di	7.20	1.71	8.35	0.00	5.45	.00		.00	37.17	42.29	36.20	44.39	30.47
hem	6.79	1.16	3.98		1.82				.00	.00	.00	.00	.00
rt											.17		

17	18	19	20	21	22	23	24	25	26	32	33	34	35
76.4	74.1	76.9	73.6	75.6	72.3	63.0	70.6	68.2	66.6	59.3	61.7	58.8	53.8
13.2	12.3	12.1	15.2	14.1	14.5	16.1	16.3	16.9	15.9	18.0	18.7	15.7	15.0
1.56	2.17	1.85	.64	1.25	3.74	1.26	.75	.64	.80	7.6	6.2	9.2	9.4
.00	.00	.00	.00	.00	.00	4.14	.81	1.95	2.92				
.26	.30	.64	.10	.23	.48	2.25	.39	1.02	.94	3.8	2.9	2.7	3.9
1.01	2.62	.72	1.29	1.38	.63	5.55	2.33	3.01	4.78	7.9	5.8	6.6	12.3
2.13	4.02	2.30	5.02	4.56	3.86	3.77	5.45	5.07	2.40	3.2	3.8	1.1	0.9
3.74	1.67	2.88	2.22	1.48	2.39	.58	1.90	1.49	2.80	0.2	0.7	2.5	0.2
.19	.26	.18	.23	.15	.34	.63	.15	.34	.49	0.8	0.1	0.6	0.8
.00	.00	.00	.00	.00	.00	.16	.07	.09	.01	0.1	Tr	0.1	0.3
.00	.00	.00	.00	.00	.00	.02	.01	.01	.01				
.00	.00	.00	.00	.00	.00	.10	.03	.04	.09				
.00	.00	.00	.00	.00	.00	.12	.12	.20	.13				
1.51	2.56	2.43	1.70	1.25	1.76	1.37	.35	.77	.63				
.00	.00	.00	.00	.00	.00	.16	.11	.00	.14				
100.00	100.00	100.00	100.00	100.00	100.00	99.21	99.37	99.73	98.64	100.9	97.5	97.5	96.6
						2.78	2.67	2.69	2.75				
An_{21}	An_{23}	An_{15}	An_{12}	An_{14}	An_{8}	An_{48}	An_{19}	An_{24}	An_{52}	An_{54}	An_{41}	An_{76}	An_{82}
1.8	3.5	3.3	0.73	1.5	4.8	14	2.6	6.1	7.8	20.5	16.8	19.7	32.9
< 1	< 1					< 1	< 1	< 1	< 1				
731	180					90	290	270	180				
						< 1	< 1	< 1	< 1				
< 5	< 5					15	< 5	6	10				
< 5	< 5					50	5	20	15				
< 5	< 5					20	< 5	10	20				
20	< 10					20	20	10	10				
25	7					8	7	20	9				
240	320												
< 10	< 10					< 10	< 10	< 10	< 10				
< 5	< 5					35	< 5	15	10	74	54	111	63
< 10	< 10					< 10	< 10	30	< 10				
< 10	< 10					20	< 10	< 10	< 10				
1	1					1	< 1	< 1	< 1				
100	100					300	500	300	100	343	210	193	309
80	50					100	60	80	100				
15	30					10	< 10	< 10	< 10				
50	40					70	35	30	65				
400	400					200	400	400	200	133	126	147	159
										4993	4442	4801	5293
.00	.00	.00	.00	.00	.00	.00	.15	.19	.02	210	108	223	675
.00	.00	.00	.00	.00	.00	.07	.03	.03	.04	.000	.000	.000	.000
.00	.50	.24	.00	.00	49	.90	21	.48	.71	1.119	1.010	1.187	1.198
23.04	10.14	17.93	13.34	8.90	14.62	3.54	11.30	8.88	17.26	1.188	4.288	15.754	1.272
19.92	34.92	21.74	45.79	41.70	35.84	34.98	49.22	45.89	22.45	28.853	35.338	10.522	8.689
5.22	10.87	3.76	6.50	6.9	3.23	26.15	11.17	14.46	24.65	34.316	24.570	32.516	39.044
4.33	.00	4.47	2.43	2.7	4.98	.00	1.33	1.86	.28	.000	.000	.000	.000
.00	.00	.00	.00	0	1.99	1.36	.78	.68	.87	2.415	2.382	2.562	2.586
.00	.45	.00	.00	.0	.00	.00	.00	.00	.00	.000	.000	.000	.000
1.13	1.59	1.23	45	.8	.00	.00	.00	.00	.00	.000	.000	.000	.000
.00	.15	.50	.00	.0	1.37	6.14	1.08	2.84	2.70	9.319	6.875	7.593	5.704
.74	.00	1.86	.28	.6	.92	4.69	.54	2.15	3.53	4.149	2.634	7.030	3.804
.00	.00	.00	.00	.0	36.54	20.82	24.18	22.54	27.48	14.915	18.873	21.269	17.445
45.47	39.82	48.75	31.04	37.9	.00	.55	.00	.00	.00	2.432	2.834	698	11.748
.00	1.66	.00	.00	.0						1.083	1.086	646	7.834
.13			.16	.11									

SEE NEXT PAGE FOR CODES

SiO_2 Analysis

Sample	SiO_2
27	64.5
28	62.7
29	50.0
30	80.7
31	69.2

CODE FOR TRACE ANALYSES SYMBOLS

Symbol	Element	Symbol	Element
Ag	Silver	Ni	Nickel
Ba	Barium	Pb	Lead
Be	Berylium	Sc	Scandium
Co	Cobalt	Sn	Tin
Cr	Chromium	Sr	Strontium
Cu	Copper	V	Vanadium
Ga	Gallium	Y	Yttrium
Li	Lithium	Zn	Zinc
Mn	Magnesium	Zr	Zirconium
Mo	Molybdenum		

CODE FOR MOLECULAR NORMS TABLES

Symbol	Mineral	Symbol	Mineral
ap	Apatite	en	Enstatite
po	Pyrrhotite	fs	Ferrosilite
il	Ilmenite	q	Quartz
or	Orthoclase	di	Diopside
ab	Albite	hed	Hedenbergite
an	Anorthite	rt	Rutile
cor	Corundum		
mag	Magnetite		
hem	Hematite		
wo	Wollastonite		

TABLE 8a: SUMMARY OF CHEMICAL ANALYSES ON ROCKS FROM HOUGHTON-HOUGH LAKES AREA.

Sample No.	Field No.	Analysis	Field Classification	Chemical Classification (Irvine and Baragar 1971)	Chemical Classification (Jensen 1976)
1	125	whole	m-cg* mafic flow	tholeiitic, high alumina basalt	tholeiitic basalt
2	167	whole	intermediate crystal tuff	calc-alkaline andesite, high alumina	calc-alkaline andesite
5	128	whole	intermediate pyroclastic	calc-alkaline andesite, high alumina	calc-alkaline dacite
6	2	whole	intermediate porphyritic flow	calc-alkaline andesite	calc-alkaline andesite
8	5	partial	intermediate flow	calc-alkaline basalt	calc-alkaline andesite
9	1000	partial	intermediate pyroclastic	tholeiitic dacite	tholeiitic rhyolite
10	4	whole	fg* felsite	calc-alkaline dacite	calc-alkaline rhyolite
11	3063	whole	fg* felsic flow	calc-alkaline rhyolite	calc-alkaline rhyolite
12	338	whole	felsic flow or tuff	calc-alkaline rhyolite	calc-alkaline rhyolite
13	38	whole	fg* felsic flow or tuff	calc-alkaline rhyolite	calc-alkaline rhyolite
14	109	partial	fg* felsic tuff	calc-alkaline rhyolite	calc-alkaline rhyolite
15	158	partial	felsic tuff	calc-alkaline dacite	calc-alkaline rhyolite
16	259	partial	felsic to intermediate crystal tuff	calc-alkaline dacite	calc-alkaline rhyolite
17	281	partial	felsic crystal tuff	calc-alkaline dacite	calc-alkaline rhyolite
18	344	partial	porphyritic (quartz) felsic to intermediate flow	calc-alkaline dacite	calc-alkaline rhyolite
19	355	partial	porphyritic felsic flow	calc-alkaline rhyolite	calc-alkaline rhyolite
20	3191	partial	felsic pyroclastic	calc-alkaline rhyolite	calc-alkaline rhyolite
21	3215	partial	fg* felsic flow	calc-alkaline rhyolite	calc-alkaline rhyolite
22	3398	partial	felsic to intermediate tuff	calc-alkaline rhyolite	calc-alkaline rhyolite
23	3146	whole	porphyritic quartz diorite	quartz diorite	
24	3141	whole	intermediate quartz-feldspar porphyry	trondhjemite	
25	199	whole	f-mg* trondhjemite	trondhjemite	
26	3108	whole	mg* trondhjemite	quartz gabbro (high norm plagioclase)	
27	1	SiO_2	intermediate cg* flow		
28	85	SiO_2	intermediate crystal tuff		
29	300	SiO_2	mafic mg* basalt flow	calc-alkaline basalt, high alumina	calc-alkaline andesite
30	3365	SiO_2	felsic quartz feldspar porphyritic flow	calc-alkaline andesite, high alumina	calc-alkaline andesite
31	3376	SiO_2	felsic to intermediate crystal tuff	tholeiitic basalt, high alumina tholeiitic basalt	tholeiitic dacite (borderline-probably) calc-alkaline andesite
32	56**	partial	intermediate flow		calc-alkaline basalt
33	332**	partial	intermediate tuff/ash or sediment (matrix of hyaloclastic breccia) from mixed volcanic unit		
34	186**	partial	intermediate tuff or sediment		
35	325**	partial	mafic volcanic clot		

*fg = fine-grained, mg = medium-grained, cg = coarse-grained
**denotes sample analysis taken from Bulmer (1976)

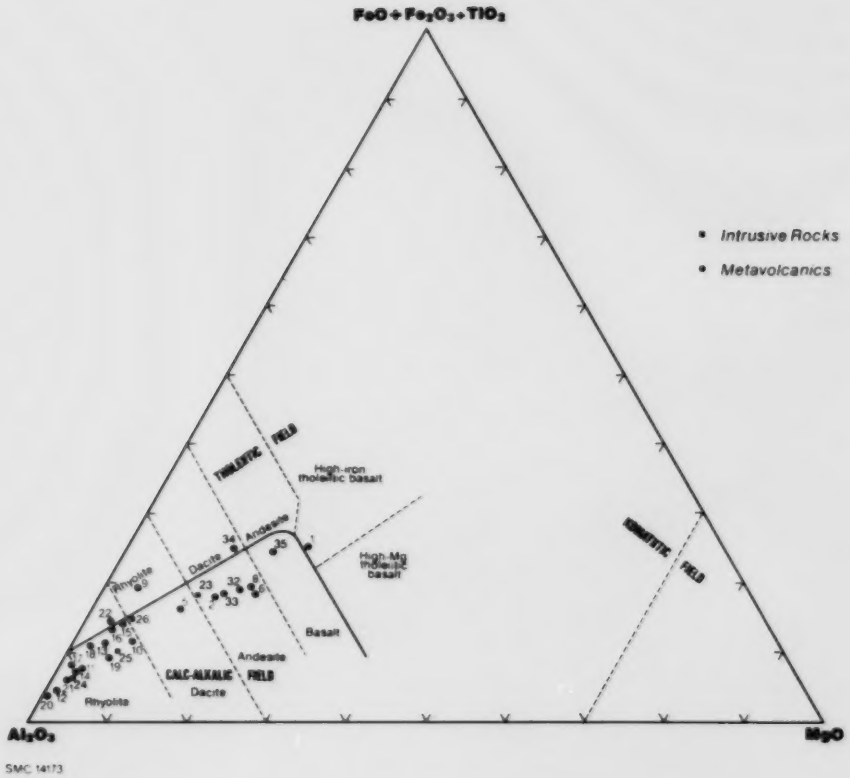


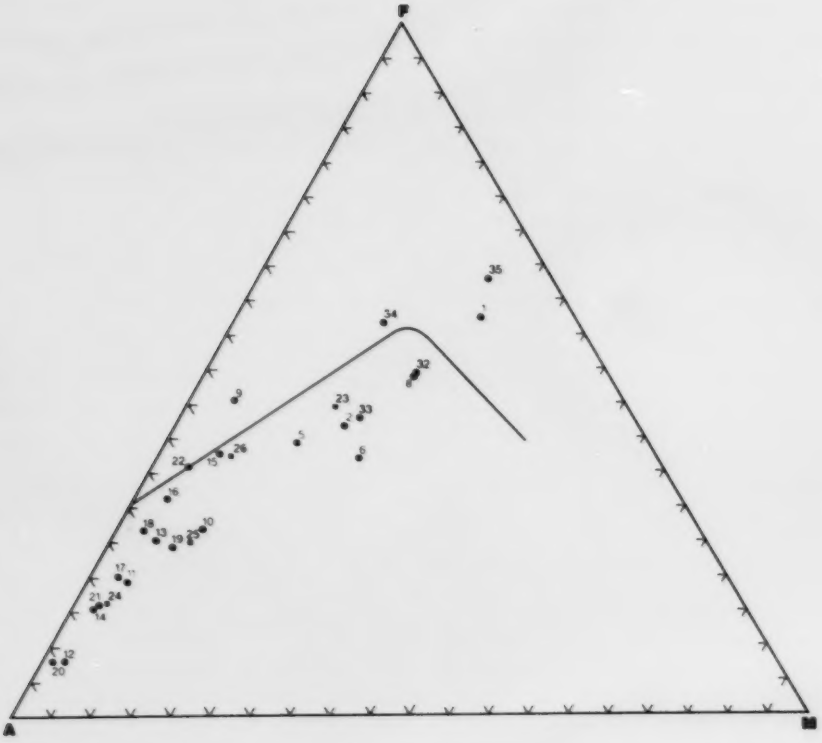
Figure 2–Jensen Cation plot of volcanic and intrusive rocks in the Houghton-Hough Lakes area.

gin but verification of this parentage is impossible due to the affects of recrystallization.

Southwest of Exploration Lake, scarce (1 to 2 percent by volume) subhedral plagioclase laths are present in the intermediate metavolcanics (map code 2p). Thin section examination shows that some of these are secondary porphyroblasts. The porphyroblasts averages 0.7 to 1.5 mm in size in a matrix (<0.15 mm) that is aphanitic in the field. Due to its scarcity and fine grain size, the porphyroblastic feldspar is hard to distinguish in the field. Some of the feldspars are possibly primary in origin but this is hard to substantiate due to the degree of recrystallization.

Felsic Metavolcanics

Felsic metavolcanics underlie approximately 15 percent of the map-area and include rocks of rhyolitic, rhyodacitic, and locally dacitic compositions. All of the



SMC 14174

Figure 3–AFM plot of volcanic and intrusive rock in the Houghton-Hough Lakes area.

felsic metavolcanics in the map-area form intraformational, compositionally distinct layers in the Handy Lake Volcanic Sequence south of Kashaweogama Lake. Within this dominantly intermediate and felsic metavolcanic sequence the felsic metavolcanics form three separate fairly extensive formations and several minor units. The three main formations are situated (1) along the south end of Hough Lake, (2) as a thick formation within the centre of and continuous across the map-area from Evans Lake to Island Lake to west of Houghton Lake, and (3) approximately 1.6 km west of Evans Lake along the south margin of the map-area.

These three formations delimit areas that are predominantly felsic in composition, i.e. there are minor intercalated intermediate metavolcanics within this sequence which, because of the present scale of mapping as well as the lack of continuous exposure, are not distinguished. Two, less extensive, discontinuous formations are also intercalated with metasediments and intermediate metavol-

canics north of Hough Lake. No apparent repetition of these major felsic formations is evident and it would appear they are successive units that young to the north. In places the composition of some of the rocks was observed to be close to the intermediate-felsic compositional boundary and these rocks were further designated by a supplementary code (map code 3j). Felsic metavolcanics contain 0 to 18 percent mafic minerals (mainly biotite) but in the field, due to their aphanitic grain size, much of the mafic content was not visible and many of the rocks classified as felsic volcanic were observed to have an apparent field colour index of around 5 percent or less. The felsic metavolcanics typically weather white to locally pink and are light grey to light beige to locally pink on the fresh surface. Exposed surfaces of felsic metavolcanics in the field tend to be smooth, flat to gently rounded and less foliated in direct contrast to intermediate metavolcanics which are generally more hackly and foliated on the weathered surface.

Aphanitic to fine-grained porphyritic flows and the finer pyroclastic rocks (tuff, lapilli-tuff) are the dominant lithologies found in the felsic metavolcanic formations. Tuff-breccia, crystal tuff, bedded tuff deposits, ash-flow tuff, massive flows, and flow breccia are also present.

MINERALOGY

The felsic metavolcanics have been metamorphosed to greenschist metamorphic conditions in the northern part of the map-area and to amphibolite metamorphic conditions in the south. Metamorphic grade is for the most part hard to define due to lack of metamorphic index minerals. The rare index minerals observed are generally too fine grained to be evident in the field. In the absence of index minerals, the presence of amphibolite facies metamorphic grade in thin section was suspected largely on the basis of the absence of chlorite in the presence of muscovite (Winkler 1974) and the presence of a highly recrystallized granoblastic-polygonal texture in which quartz, plagioclase, muscovite, and biotite are almost the sole constituents.

The minerals encountered in the felsic metavolcanics include quartz + plagioclase + muscovite ± biotite ± epidote ± chlorite ± carbonate ± tourmaline (schorlite) ± microcline ± rare sphene ± rare hornblende ± opaques (magnetite, hematite, pyrite) ± garnet ± rare andalusite ± rare kyanite.

Quartz and plagioclase together form 68 to 90 percent of the felsic volcanic rocks and are the dominant constituents. Commonly, they are recrystallized and are indistinguishable in thin section forming a very fine grained groundmass that averages less than 0.15 mm. Where quartz and feldspar form phenocrysts or tuff-crystal fragments they are generally coarse enough (2.0 mm on the average, locally up to 4.0 mm) to be visible in hand specimen. Coarse quartz crystals in pyroclastic rocks are usually polycrystalline, commonly completely recrystallized and are subhedral in character. In porphyritic flows and subvolcanic flows the quartz varies from conspicuous iridescent blue, milky white to clear grey in the field; in thin section this quartz is only weakly recrystallized, locally traversed by clean fractures and is subhedral to euhedral.

Plagioclase in the greenschist metamorphic facies is albitic in composition. In the higher metamorphic facies the composition ranges from An_{20} to An_{34} (oli-

goclase-andesine) but averages An_{25} to An_{30} (calcic oligoclase). Matrix plagioclase is generally finely recrystallized and appears similar to quartz but locally subhedral microlites (0.18 mm) are preserved in felsic flows. Coarse plagioclase, present as phenocrysts in flows and crystal fragments in pyroclastic rocks, is subhedral to euhedral and commonly fractured. In the greenschist metamorphic facies, the plagioclase generally exhibits a combination of pericline, Carlsbad, and albite twinning and is lightly sericitized. Plagioclase metamorphosed under amphibolite metamorphic grade is generally subhedral to anhedral, recrystallized especially along the margins and locally is poikiloblastic. The poikiloblastic texture is characterized by rounded inclusions of quartz and/or plagioclase crystals. With the latter, the plagioclase inclusions may actually represent an exsolved phase of plagioclase different in composition from the host.

With respect to the micaceous minerals, muscovite (5 to 15 percent) is generally more plentiful than biotite (0 to 15 percent); chlorite (5 percent) is the least common. Biotite and muscovite typically form separate, thin, tabular crystals (1 mm) and are rarely intergrown. In the amphibolite metamorphic facies, biotite frequently forms loosely aggregated, subaligned clots (2 to 3 mm x 1 to 2 mm) in which the individual biotite crystals are randomly oriented. These clots weather out giving weathered surfaces a pitted appearance. The biotite is generally aligned and commonly distributed unevenly in the greenschist metamorphic facies but tends to be randomly oriented and uniformly distributed in the amphibolite facies. Muscovite is nearly always foliated in all metamorphic grades; rarely, it is randomly oriented in the amphibolite facies. In the vicinity of the major fold axis in the southeastern part of the map-area muscovite has developed along two foliation planes in which an older foliation that parallels the stratigraphy is cut by a younger foliation that parallels the fold axis. Chlorite (penninite) is commonly intimately intergrown with biotite in the southeastern part of the map-area where it represents a product of retrograde metamorphism. Elsewhere, in the greenschist metamorphic facies, chlorite is found associated with and prograding to biotite.

Hornblende (1 to 2 percent) is present as subhedral, randomly oriented, poikiloblastic crystals only in the felsic volcanic unit on the east shore of Hough Lake where it is a contact metamorphic mineral possibly related to felsic porphyritic intrusive rocks.

Calcite (0 to 10 percent) is particularly abundant in the vicinity of Hough Lake. It frequently exhibits an affinity for plagioclase crystals and is probably an alteration mineral produced during albitization of the plagioclase. However, in the Hough Lake area it is so abundant (up to 8 to 10 percent) that some of the calcite had to have been introduced from an external source.

Minor occurrences of andalusite and kyanite (N. Trowell, personal communication) are present locally in the southeastern part of the map-area within felsic metavolcanics. Andalusite was observed as very small crystals (<0.18 mm) in one thin section and is generally not coarse enough or concentrated enough to be visible in the field. The kyanite, present as elongated blades, was observed in the field (N. Trowell, personal communication) at one locality 0.4 km west of the north part of Evans Lake.

Dark blue-black tourmaline (schorlite) is locally concentrated (up to 1 percent) in the felsic metavolcanics; it occurs as single prismatic crystals that are too small to be distinguished from hornblende in the field. Trowell (1974, p.14)

also mentions the presence of tourmaline in felsic volcanic rocks in the Sturgeon Lake Greenstone Belt.

Microcline feldspar (1 to 2 percent) that characteristically exhibits polysynthetic twinning is locally present as anhedral poikiloblasts in felsic metavolcanics of amphibolite metamorphic grade.

MASSIVE AND PORPHYRITIC FLOWS

Porphyritic felsic metavolcanic flows are present within the felsic metavolcanic formations. These porphyritic felsic metavolcanics are thought to be extrusive for the most part but rare exposed crosscutting relationships indicate that some of these rocks are subvolcanic.

Massive and porphyritic flows constitute approximately 10 percent of the felsic metavolcanic sequence and are most abundant in the felsic metavolcanic formation situated 1.0 km north-northwest of Evans Lake. The majority of the felsic flows are characterized by sparsely distributed quartz (2 to 8 percent) and/or feldspar (5 to 10 percent) phenocrysts. Except for a unit that characteristically contains abundant quartz phenocrysts situated 3.2 km west of Island Lake, in generai, feldspar phenocrysts are much more common than quartz phenocrysts. In those felsic flows that are nearer to the intermediate composition range, the density of the quartz and feldspar phenocrysts is generally greater (about 15 and 25 percent, respectively). The plagioclase and quartz phenocrysts always occur singly and are fairly evenly distributed. Plagioclase phenocrysts are randomly oriented, commonly lath-shaped, and are commonly fractured. Quartz phenocrysts weather from grey-white to clear grey to locally iridescent blue and are more conspicuous in the field than the feldspar phenocrysts. The more siliceous felsic flows are generally massive whereas the less siliceous variety are commonly foliated and this foliation wraps around the phenocrysts. The fractured nature of the phenocrysts in these flows is similar in character to those in the crystal tuffs and some of the rocks classified as porphyritic flows may, in part, be of pyroclastic origin. Nonporphyritic, massive flows are commonly intimately associated with the porphyritic flows; they are generally very fine grained and are easily confused with the finer grained felsic pyroclastic rocks especially in amphibolite facies metamorphic grade.

The large mass of felsic volcanic rocks just west of Highway 599 and just north of Evans Lake is predominantly massive, featureless, and very siliceous in appearance. Flow-banding is present at several localities in the felsic flows in the southeastern part of the map-area. The banding averages 1.2 to 2.5 cm in thickness and is discontinuous due to brecciation during extrusion. Chemical analyses (Samples 10,11, 13; Table 5) indicate SiO_2 values over 72 percent and these rocks are compositionally calc-alkaline rhyolites. In the field these rocks are observed to be very fine grained to locally medium grained and highly recrystallized to a sugary texture. Locally, these rocks are garnetiferous. The igneous origin of these rocks is confirmed by the presence of sparse, euhedral, commonly fragmented feldspar phenocrysts. Locally in the southeast part of the map-area these rocks exhibit rare breccia-like structures that are thought to be due to the affects of degassing. Fragments within these latter brecciated zones are typically

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Photo 10–Vein network of late quartz veins injected along fractures in rhyolitic tuff or flow. From large felsic mass in southeastern part of the map-area. Pen is about 16 cm in length.

monolithologic and of similar composition to the surrounding host matrix; they are mutually angular and generally only slightly displaced. Silicified felsite veins and quartz veins are commonly injected into this large felsic volcanic sequence just north of Evans Lake having been injected along a network of crisscrossing fractures (Photo 10). The quartz veins are free of mineralization. Farther west along the two arms extending west from this large felsic volcanic mass the felsic volcanics are more tuffaceous in character. The abundant presence of what appear to be massive and porphyritic flows and the presence of local tuff-breccia units suggest that this is a felsic volcanic centre. The massive nature, areal extent, roughly equidimensional area covered by the felsic mass, and the local brecciation of the flows indicate that the rocks comprising this felsic centre may be of intrusive, subvolcanic origin. The brecciation of the intrusive rocks could be the result of either autobrecciation during movement or degassing (fumerolic) action.

PORPHYRITIC FELSIC METAVOLCANICS OF SUBVOLCANIC ORIGIN

A unit of felsic quartz and feldspar-quartz porphyry extending from just north of Houghton Lake east-southeast towards Island Lake exhibits discordant contacts in a few exposures indicating it is intrusive in part. Intrusive relation-

ships including rare crosscutting relations and a few possible mafic inclusions are mainly found near the margin of the porphyritic unit on the west shore of the small lake situated 0.12 km northeast of Houghton Lake. However, this porphyritic unit is spatially associated with fairly extensive felsic pyroclastic rocks including a lapilli-tuff unit in which the fragments appear to have formed around quartz phenocrysts (map unit 3W). The latter are similar to the quartz phenocrysts in the porphyritic unit suggesting it is contemporaneous with the pyroclastic volcanism. The quartz phenocrysts (2 to 3 mm) are commonly iridescent blue and are distinctive in the field whereas the feldspar phenocrysts (2 to 5 mm) weather white and tend to blend into the white weathering matrix. The matrix is aphanitic, composed of indeterminant proportions of recrystallized quartz and feldspar.

FLOW BRECCIA

Felsic flow breccia is restricted to a single exposure on the small road forming the west loop off Highway 599 just west of Evans Lake. This exposure has since been covered over by gravel during recent construction of the new road extending across the south part of the map-area. The flow breccia consists of large white-weathering masses of felsic flow material intercalated with equal amounts of felsic to intermediate volcanic material.

FELSITE

The term "felsite" was used in context with those felsic metavolcanics of indeterminate (extrusive or intrusive) origin. These rocks are mainly found in the southeastern part of the map-area and characteristically are composed of an aphanitic massive mosaic of recrystallized (granoblastic) quartz and feldspar producing a sugary texture in hand specimen. Some of the thin (15.24 to 30.48 m), felsic, sill-like lenses intercalated within the intermediate metavolcanic sequence just west of Evans Lake are massive, relatively featureless units and may in part fit into this category. In other similar thin lenses the presence of sparse felsic fragments and thin bedding (Photo 11) (2.5 to 3.8 cm) attest to a pyroclastic origin. Sulphide mineralization (pyrite, chalcopyrite) is associated with some of these thin units.

PYROCLASTIC ROCKS

Tuff, Lapilli-Tuff, and Tuff-Breccia

Approximately 70 percent of the felsic metavolcanic sequence is composed of pyroclastic rocks. Fragments vary from ash- to lapilli- to bomb-size (tuff-breccia) (Fisher 1966) but are predominantly within the size range encompassed by la-

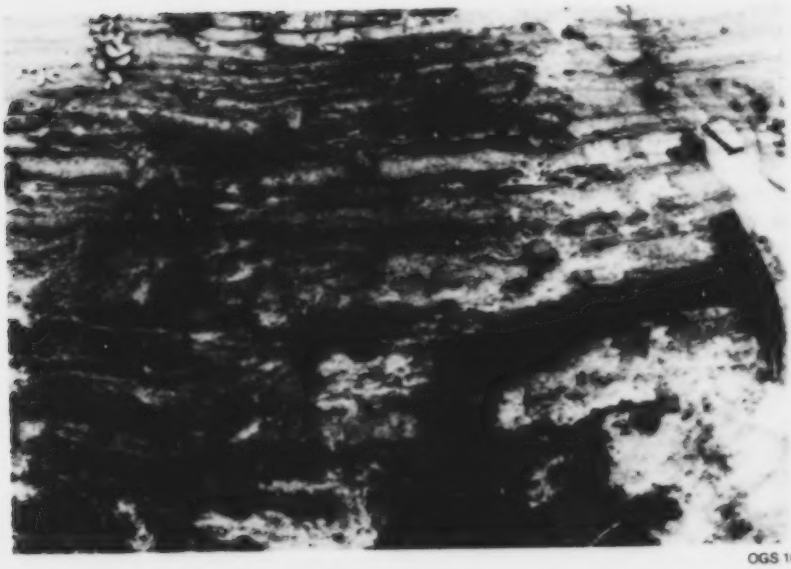

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Photo 11–Thinly bedded ash-fall felsic tuff or reworked felsic tuff horizon in felsic formation just south of mixed volcanic unit and just west of Evans Lake.

pilli-tuff (2 to 64 mm). The coarsest felsic pyroclastics composed of bombs (approximately 30 to 50 cm in the direction of the exposed long axis) are restricted to three areas: the fairly thick felsic volcanic formation extending between Island Lake and Houghton Lake, the extreme southeastern flanks of the large felsic mass situated immediately north-northwest of Evans Lake, and the felsic formation situated just west of the small lake 4 km west of Evans Lake. In addition to the above, crystal tuff and reworked felsic tuff are also present within the map-area. In greenschist facies, primary texture (i.e. the outline of fragments) is well preserved. In the rocks of the amphibolite facies metamorphic grade the fragments are more obscure especially where the composition of the fragments approximates the composition of the matrix. However, in general the fragments are slightly more felsic in composition relative to the matrix, and lapilli- or greater-sized fragments are distinguishable throughout the map-area. Felsic tuff, lapilli-tuff, and tuff-breccia form almost the entire sequence of the felsic formations situated along the south side of Hough Lake as well as 2.4 km west of Evans Lake along the south boundary of the map-area.

These same pyroclastic rocks form a large part of the formation between Houghton Lake and Island Lake. Some of the coarse fragments in this latter area are compositionally similar to the matrix and are extremely indistinct in the field. Most fragments are lenticular although coarser fragments tend to be less elongate and more subrounded. Fragments within individual pyroclastic ex-

posures vary in composition from heterolithic to monolithic but the latter is most common. In thin section fragments are distinguished by being more finely recrystallized than the adjacent matrix and by a substantial variation in abundance, type, and habit of their mafic minerals, i.e. in general the mafic minerals are randomly oriented, more evenly distributed, and less abundant in the fragments.

The amount of matrix in the coarser pyroclastic rocks varies haphazardly but in general appears to form about 30 percent of the rock. Approximately 300 m south of Hough Lake, a unit of lapillistone with little to no matrix is present. The fragments are indistinct and this may in fact be an ignimbrite. In the greenschist facies the matrix tends to be foliated to locally schistose. This foliation is less prominent and more widely spaced than in similar rocks of more intermediate compositions.

The majority of the pyroclastic rocks occur in thick massive units. Distinctive, individual pyroclastic units are rare and are too discontinuous to separate stratigraphically at the present scale of mapping. Bedding was observed only rarely in the felsic pyroclastic deposits. It is the author's opinion that, because of the lack of bedding, many of these rocks have originated as ash flows. Near the northeast shore of Houghton Lake, within finely laminated tuff, rare disrupted (brecciated), laminated tuff fragments were noted. The haphazard orientation of the fracturing and brecciation of these laminated tuff fragments suggests the deformation was primary and not secondary. Such a texture is most easily attributed to brecciation caused during movement of an ash flow and this rock is termed an ash-flow breccia (map code 3y).

Lapilli-Tuff Fragments with Cavities

An unusual lapilli-tuff is restricted to two exposures near the south shore of the small lake 1.2 km northeast of Houghton Lake. There, felsic fragments (approx. 2.0 cm) occur within a felsic to intermediate matrix containing 10 to 15 percent quartz and less abundant feldspar crystal fragments. The lapilli-tuff unit (map code 3w) is unusual in that the fragments are characterized by elongated central cavities. The elongation of the cavities is parallel to the direction of elongation of the fragments. Some of the centres are inhabited by quartz phenocrysts, but most are vacant and appear as pits within the centres of the lapilli fragments on the weathered surface. The pits or cavities may be the result of plucking of the quartz phenocrysts by weathering processes. A single thin section of the fragments indicated they are more felsic than their matrix and are composed of a granular intergrowth of quartz and feldspar. In general the grain size decreases from the centre to the margins of the fragments but no accumulatory growth lines or radiating structures were noted. A few quartz crystals are present in the outer margin of the fragments. Minor carbonate is present in the central cavity zone. This rock is spatially associated with quartz and quartz-feldspar porphyritic flows. The presence of porphyritic crystal fragments in the matrix of the lapilli-tuff implies that it is related to the same volcanism that gave rise to the porphyritic flows. It is possible that the quartz in some of the central cavities is related to the porphyritic magma but it may also be secondary

having filled vacant cavities within the fragments subsequent to their eruption. The origin of the cavities may be related to degassing during eruption. No radiating or ring structures that could indicate these are spherulites were observed in thin section.

Crystal Tuff

Crystal tuff is sporadically dispersed throughout the felsic volcanic rocks but is most abundant within felsic volcanic formations between Houghton Lake and Island Lake, between Moosolf Lake and Fairchild Lake, and south of Exploration Lake.

Phenocrysts of quartz and/or plagioclase feldspar constitute the crystal fraction in the crystal tuffs. Crystal tuff is distinguished from porphyritic flows in the Houghton-Hough Lakes area by the following:

1. crystal tuff has a greater abundance of crystals, generally from 25 to 40 percent of the rock whereas porphyritic rocks generally contain less than 25 percent phenocrysts;
2. crystals within crystal tuff exhibit a greater degree of fragmentation;
3. crystal tuff has a more pronounced foliation;
4. distribution of the crystals in crystal tuff is locally heterogeneous whereas, in porphyritic rocks, the distribution is fairly uniform;
5. the iridescent blue-weathering coloration of the quartz crystals appears to be more common in the porphyritic rocks than in crystal tuffs.

The distinction between the two rock types was not always resolvable. The most reliable evidence is the local presence of volcanic fragments.

Quartz and feldspar crystal fragments vary from almost aphanitic up to approximately 7 mm and are commonly 1.0 to 2.5 mm. They are generally randomly oriented although, in more highly schistose varieties as in the crystal tuff unit between Moosolf and Fairchild Lakes, elongated crystal fragments tend to conform to the direction of regional foliation. In the greenschist facies the quartz is subrounded, unrecrystallized except locally around the margins and is, in places, fractured. Plagioclase crystals are commonly fractured, subhedral, angular to subrounded, altered to sericite and are unzoned. Rare lithic fragments are locally discernible in the matrix. In strongly foliated varieties the foliation wraps around the crystal fragments and quartz crystals are more commonly strung out as lenses. In the amphibolite facies the quartz and feldspar crystal fragments, although more recrystallized and less definitive in thin section, are still fairly prominent in the field.

Bedded Tuff Deposits

Bedded tuff horizons (map code 3h) (Photo 11) are exceedingly rare and are restricted to several isolated occurrences. They are present in the first thin felsic horizon just west of Evans Lake, stratigraphically south of the mixed metavolcanic unit, and in the felsic unit south of Fisher Lake. Bedding units are gener-

ally thin (0.63 to 2.17 cm), massive, ungraded and do not exhibit any noticeable current structures. Bedding planes in these deposits are typically indistinct both in the greenschist and amphibolite metamorphic facies.

Volcanic Stratigraphy Summary Statement

Volcanic activity in the Houghton-Hough Lakes map-area gave rise to markedly different volcanic sequences. The sequence exposed north of Kashaweogama Lake is uniformly basaltic in composition comprising massive flows and locally nonvesicular, pillowed flows indicative of a fairly deep, subaqueous origin. This sequence is similar in character, is equivalent to, and is continuous with the Jutten Volcanic Sequence exposed in McCubbin Township (Bond 1977) and Jutten Township (Bond 1979).

The sequence south of Kashaweogama Lake is composed of a complex, intermixed, layered succession of mafic intermediate and felsic metavolcanics interrupted by five separate metasedimentary formations. This sequence is herein referred to as the "Handy Lake Volcanic Sequence". These rocks range in composition from basalt to rhyolite that form compositionally distinct formations ranging in thickness from 90 to 2000 m. The Handy Lake Volcanic Sequence is similar to upper volcanic cycles observed in other Archean volcanic sections (Morrice 1974).

The dominant part of the Handy Lake Volcanic Sequence exposed in the Houghton-Hough Lakes area is composed of intermediate and felsic tuffs and lapilli-tuffs, and massive, equigranular and porphyritic flows. The generally fine fragment size of the pyroclastic accumulations imply that most of the Handy Lake Volcanic Sequence exposed in the map-area represents a fairly distal environment, for example, the outer flanks of a volcano. The large felsite mass just north of Evans Lake represents a possible tributary feeder zone or possibly a main volcanic centre for the felsic volcanism. The rare presence of pillow structures and amygdules within the mafic volcanic formations and of hyaloclastic breccia within the mixed (intermediate mafic) volcanic unit indicates that the Handy Lake Volcanic Sequence is dominantly subaqueous in origin. Near the upper part of this sequence, interlayered sedimentary units are more common. The presence of bedded tuffs of possible air-fall origin in the vicinity of Hough Lake and the presence of laharic breccia in Conant Township (east of the map-area) (Bond 1979) suggests parts of the upper part of the Handy Lake Volcanic Sequence, may have been formed under subaerial conditions.

Geochemistry

Both partial and whole rock chemical analyses of 27 metavolcanic rocks and 4 intrusive rocks are given in Table 5. A summary comparing field and chemical classifications is given in the accompanying Table 5a and Figure 4 (Chart A, back pocket) shows the approximate location of the samples. Except for samples 32 to 35 inclusive, which are taken from Bulmer (1976), all of the analyses were

done by the Geoscience Laboratories, Ontario Geological Survey. The chemistry of the intrusive rocks is discussed later in this report under the appropriate section. Whole rock analysis was done on representative volcanic rock types. In order to substantiate the presence of felsic volcanic varieties, emphasis was placed on sampling the more felsic parts of the volcanic sequence and these were submitted for partial analysis. The metavolcanic samples are all taken from the Handy Lake Volcanic Sequence south of Kashaweogama Lake.

The rocks have been classified according to Jensen (1976) and are plotted on a Jensen Cation Plot (Figure 2). For comparative purposes, some of the samples are also classified on the basis of normative plagioclase composition versus normative colour index after Irvine and Baragar (1971) and these are listed in Table 5a. In general, the two classifications are in approximate agreement although there is a tendency for the samples to plot slightly more mafic when plotted according to Irvine and Baragar (1971). Those samples affected (Nos. 5, 9, 10, 15, 16, 17, and 18) all have relatively high normative plagioclase composition when compared with rocks of similar composition. Abundant carbonate alteration is present in parts of the map-area and is probably a factor in the high normative plagioclase composition. For this reason the classification scheme of Jensen (1976), because it is based on low migratory elements, is considered more acceptable for the Houghton-Hough Lakes area. The analyses indicate that the rocks mapped as mafic are basaltic in composition; the intermediate rocks are andesitic to dacitic in composition, and the felsic volcanics are rhyolitic in composition. Although rhyolite is prominent in the chemical classification, undoubtedly the felsic parts of the sequence are not entirely or uniformly rhyolite in composition but probably range from rhyolite to upper dacite.

Both the AFM Plot (see Figure 3) and the Jensen Cation Plot (see Figure 2) indicate that the Handy Lake Volcanic Sequence is calc-alkaline. The mafic metavolcanic sample (analysis number 1) plots in the iron tholeiitic basalt field but is still considered to be part of the calc-alkaline trend exhibited by the Handy Lake Volcanic Sequence. Samples 1, 2, and 5, are all in the vicinity of Hough Lake and have been extensively carbonatized resulting in high CO_2 values. No analyses were done on the mafic metavolcanics (Jutten Sequence) north of Kashaweogama Lake but the equivalent sequence exposed east of Savant Lake was analyzed and found to be composed mainly of tholeiitic basalt (Bond 1979).

METASEDIMENTS

Metasediments form eight separate formations within the map-area and are also locally concentrated as minor, thin units within the mixed volcanic unit just west of Evans Lake. Three of these formations including conglomerate with related finer clastic metasediments, and chert are associated with the Jutten Volcanic Sequence exposed north of Kashaweogama Lake. The remaining five formations and the isolated minor units are associated with the Handy Lake Volcanic Sequence south of Kashaweogama Lake. The three most northern metasedimentary bands in the Handy Lake Volcanic Sequence in the northeastern part of the map-area are laterally continuous with the Savant Group of metasediments (see Regional Compilation and Correlation of Supracrustal Sequences in

the Savant Lake Area, this report; Figure 5, Chart A, back pocket). The Savant Group metasediments are situated north of the Handy Lake Volcanic Sequence (Bond 1977, 1979) east-northeast of the map-area. Metasediments have been subdivided into chemical and clastic varieties. Chemical metasediments include a dominantly chert formation situated within the mafic volcanic sequence north of Kashaweogama Lake and abundant iron formation intimately interbedded with arenaceous and argillaceous clastic metasediments associated with the Handy Lake Volcanic Sequence. Clastic metasediments are found in both volcanic sequences and include sandstone, siltstone, mudstone, cherty siltstone, tuffaceous metasediments, and conglomerate. The metasedimentary formations interbedded with the Handy Lake Volcanic Sequence south of Kashaweogama Lake are thickest in the eastern part of the map-area and gradually pinch out to the west.

Chemical Metasediments

FERRUGINOUS METASEDIMENTS

Interbedded Chert-Iron-Silicate Formation

The cherty metasedimentary formation associated with the Jutten Volcanic Sequence north of Kashaweogama Lake may be the oldest metasedimentary unit within the map-area. This dominantly chert formation strikes northwest from the Kashaweogama Lake Fault for 440 m before passing out of the map-area. Near Kashaweogama Lake, the chert formation averages 275 m thick but becomes progressively thinner to the northwest where, at the north boundary of the map-area, it is less than 60 m thick. Recent reconnaissance mapping (Breaks and Bond 1976) indicates this chert formation extends northwest to slightly beyond Armit Lake (approximately 1.6 km north of Fairchild Lake). Also, west of the northwest corner of McCubbin Township (Davies *et al.* 1970), a lean (chert and iron-silicate) iron formation is exposed near the base of the mafic metavolcanic sequence. The latter is believed to be continuous with the mafic metavolcanics north of Kashaweogama Lake within the Houghton-Hough Lakes area. Company drill records and geological mapping (Assessment Files Research Office, Toronto, file 63.2115) indicate this lean iron formation is lithologically similar to the chert formation in the present map-area. These two formations may be continuous but have been disrupted in part by the Kashaweogama Lake Fault, by the intrusion of the Dickson Lake Pluton, and by the intrusion of the Heron Lake Stock (Bond 1977). If these two are continuous then this predominantly chert formation extends for 19 km and forms a major break in this part of the mafic volcanism of the area.

In the Houghton-Hough Lakes area the chert formation is composed predominantly of interbedded white-weathering chert beds (Photo 12), equally abundant black to blue-grey chert, less prominent rusty to lime green chert-sili-

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Photo 12–Disharmonic folding in interbedded white chert, blue-black chert and yellow-brown chert-iron-silicate beds. From chert-iron-silicate formation north of Kashaweogama Lake. Pen is approximately 16 cm in length.

cate beds, and some (less than 2 percent by volume) green-weathering silt horizons. A light yellow-brown stain to locally heavy rusty brown gossan is apparent on some of the weathered surfaces. Except for a few magnetite grains observed in thin section no iron oxide, sulphide, or carbonate mineral concentrations were found within the chert formation lying within the map limits. Farther west along strike magnetite- or pyrrhotite-bearing iron formation is indicated in the vicinity of Armit Lake by the presence of a closely correlative magnetic high measuring 5,000 gammas above background (61,000 gammas) as indicated on the ODM-GSC (1961) aeromagnetic map.

Bedding in the chert-iron-silicate formation is well developed, laterally continuous, and averages 0.6 to 2.5 cm thick. No internal laminations within single chert beds were observed. Within the map-area the bedding most commonly strikes N45W and dips 80 to 85 degrees north. Locally the bedding is contorted, exhibiting small disharmonic, buckle folds (see Photo 12) ranging from 12 cm to several metres in amplitude. In places fracturing across the strike of the bedding is prominent. Brecciation along these fractures is locally evident.

In thin section the chert formation is predominantly composed of quartz and a clear amphibole that was determined on the basis of both optics and XRD analysis (Geoscience Laboratories, Ontario Geological Survey) to be grunerite. The presence of grunerite indicates this chert formation is metamorphosed to medium-grade (amphibolite) metamorphic conditions. The white-weathering

and blue-black weathering chert beds are composed almost entirely of finely recrystallized quartz granules (0.15 to 0.2 mm) and minor (less than 3 percent), thin, tiny, randomly oriented grunerite crystals. Locally the grunerite is concentrated along with sparse magnetite crystals into clots (4 mm) aligned parallel to bedding planes. Beds exhibiting pinkish or rusty tones on the fresh surfaces are generally observed in thin section to carry minor hematite. The darker grey-blue-black chert beds weather more readily than the white-weathering chert beds and are more finely recrystallized (less than 0.01 mm). The yellow to lime-green beds are composed of quartz and 30 to 65 percent grunerite. The grunerite forms a fine felty mass of tiny crystals that are subaligned to bedding planes. The crystals although small, do exhibit some characteristic polysynthetic twinning. The green-weathering silt horizons were not observed in thin section but are also probably composed of amphibole. This formation represents the only iron silicate facies (Gross 1965, p.87) formation known in the Savant Lake area.

MAGNETITE IRON FORMATION

Quartz-magnetite iron formation is intimately interbedded with sandstone and mudstone metasediments and forms four separable metasedimentary formations within and adjacent to the Handy Lake Volcanic Sequence south of Kashaweogama Lake. Individual iron formation beds are too finely interbedded with clastic metasediments to be separated out and shown as discrete units on the map and are grouped with clastic metasediments in the map code. The clastic metasediments interbedded with the iron formation locally contain disseminated magnetite grains but in all other properties resemble the metasediments grouped under the "Clastic Metasediments, Sandstone, Mudstone" and are described under that section. The presence of iron formation in the Savant Lake area was first noted just after the turn of the century and subsequently documented in some detail by Moore (1910) and Rittenhouse (1936). Their descriptions mainly centred on the iron formation interbedded within the main metasedimentary sequence (The Savant Group) underlying McCubbin and Poisson Townships (Bond 1977). The iron formation unit just north of Fisher Lake is part of an iron prospect (Bond 1977, p.60-66) within that main metasedimentary sequence and was roughly delineated by Moore (1910). Iron formation also forms three separate ferruginous metasedimentary units within the upper volcanic sequence south from Fisher Lake. These three formations, continuous with those mapped by the author in Conant Township (Bond 1979), were not delineated until the present mapping. The ferruginous metasedimentary formations are restricted to the eastern part of the Houghton-Hough Lakes area.

The iron formation is all oxide facies (Gross 1965, p.86). R.J. Shegelski (1975, p.12) reported the presence of carbonate facies iron formation near the western termination of the ferruginous metasedimentary unit extending farthest west from the northern part of Shoehorn Lake. This carbonate facies was not observed during the course of the field work but based upon the presence of substantial amounts of carbonate alteration in the vicinity of nearby Hough and Shoehorn Lakes and the Kashaweogama Lake Fault as well as the absence of significant carbonate facies iron formation in the Savant Lake area, it is the

writers opinion that this carbonate is probably of secondary, hydrothermal origin.

Ferruginous metasedimentary formations range from 60 to 300 m thick. The number and width of individual iron formation beds and the percentage of magnetite to chert laminations within each iron formation bed varies but within the Houghton-Hough Lakes area, iron formation beds constitute on average 5 to 8 percent by volume of the ferruginous metasediment exposures. Individual iron formation beds are generally fairly thin; they range from 0.42 to 10.0 cm but average approximately 2.0 cm. The oxide-facies iron formation consists of delicately interlaminated, black-weathering magnetite and white-weathering chert. The thickness of these laminations ranges from 0.1 to 1.5 cm but the laminations are for the most part extremely thin (less than 0.3 cm). In general the magnetite laminae tend to be fairly thick whereas the chert laminae are thin (less than 0.3 cm). Although the magnetite to chert ratio varies, in most areas the magnetite is more abundant than chert and is estimated to constitute approximately 60 to 70 volume percent of iron formation beds. Minor folds that range in amplitude from approximately 8 to 30 cm are present but are rare. Company work by Pershland Gold Mines Limited (Bond 1977) and the government aeromagnetic map (ODM-GSC 1961) indicate the highest concentration of iron formation occurs just north and east of Fisher Lake and was termed the "Kashaweogama Lake Prospect" by R. Shklanka (1968, p.396). A selected sample of typical iron formation taken approximately 1.6 km southwest of Fisher Lake within the ferruginous metasedimentary formation between Fisher and Shoehorn Lakes was analysed by the Geoscience Laboratories, Ontario Geological Survey and found to contain 29.4 percent soluble iron.

The iron formation units are interbedded with all types of arenaceous and argillaceous metasediments encountered in the map-area but are most typically found at the top of massive sandstone or sandstone-siltstone sequences. Bedding contacts between the iron formation and associated clastic metasediments are sharp implying a definite break in metasedimentary processes.

Within the mixed volcanic unit just west of Evans Lake there are a few mafic zones or clots that are composed of essentially only amphibole, garnet, and probably biotite. These were not delineated on the map. Obviously these zones have a high iron content and it is possible these are metamorphosed iron formation similar to the amphibolite facies garnet-amphibole (biotite) schist described by Pye (1957) in the Manitouwadge area; the latter are interbedded with and grade into quartz-magnetite iron formation.

Clastic Metasediments

CONGLOMERATE

Polymictic conglomerate (map code 7a) forms a thin discontinuous unit that is traceable along Fairchild and Kashaweogama Lakes and is a continuation of the conglomerate exposed in McCubbin Township (Bond 1977; Breaks and Bond 1976). This conglomerate forms a distinctive marker horizon that was ac-

curately delineated by all of the previous workers (Moore 1928; Rittenhouse 1936; Skinner 1968). Detailed mapping (Bond 1974, 1977; Trusler 1975) and reconnaissance mapping (Breaks and Bond 1977) indicate that the westward extension of the conglomerate, from Kashaweogama Lake to Kimmewin Lake (Davies *et al.* 1970), is traceable for approximately 54 km. This conglomerate is marginal to and at the base of the Savant Group.

The part of the conglomerate within the Houghton-Hough Lakes area varies in thickness from 150 to 180 m. The conglomerate is predominantly matrix supported to locally clast supported and is poorly sorted. Stratification and grading of the clasts is not apparent. The only observed stratification is in the form of a few sandstone beds which are approximately 10 cm thick and strike parallel to the gross trend of the conglomerate formation. Later tectonic deformation has developed a foliation as revealed by the parallel elongated clasts. The conglomerate is composed of pebbles, cobbles, and boulders whose apparent, exposed maximum dimensions range from 2.5 to 25 cm. The clasts are lithologically comprised of two types of trondhjemite, felsic volcanics, quartz-feldspar porphyry, intermediate volcanics, mafic volcanics, and minor chert. In one outcrop a trondhjemite boulder measuring 61 cm across was found. The clasts are supported in a well foliated greenish grey matrix of sandstone. Generally the felsic volcanic, porphyritic, and granitoid clasts are found to be least deformed being well rounded to ellipsoidal with maximum to minimum axes ratios varying from 1:1 to 2.5:1. The more mafic and intermediate clasts are highly elongated with ratios of 15 to 20:1 and commonly are deflected around the more competent felsic clasts.

Two texturally distinct trondhjemite types are represented in the clast population: 1) a massive, medium- to coarse-grained, fairly leucocratic (colour index approximately 5) biotite trondhjemite and 2) a massive fine- to medium-grained biotite trondhjemite of about the same colour index. The coarse-grained trondhjemite clasts are similar to those observed in the eastward extension of this same conglomerate where it is exposed in McCubbin Township (Bond 1977). In the Houghton-Hough Lakes area these coarse trondhjemite boulders are smaller in size and less abundant than in McCubbin Township whereas the fine- to medium-grained trondhjemite clasts are more plentiful. Except for differences in grain size the two trondhjemite phases appear similar; both have an interlocking allotrimorphic, equigranular texture and are composed of plagioclase and quartz with minor clots of biotite. A few of the granitoid clasts weather pink as a result of hematite staining.

The volcanic clasts are aphanitic to fine grained and are predominantly derived from flows. Due to their greater competency, the more siliceous (felsic) clasts are less distorted, appear larger, and are more easily observed in outcrops. On the other hand, the highly deformed mafic to intermediate clasts tend to blend into and are easily confused with the actual matrix. A few granular quartz pebbles were observed on the conglomerate exposures near the west end of Kashaweogama Lake and these may be related to the chert formation within the Jutten Volcanic Sequence to the north. No bedding was observed in any of these quartz clasts and it is also possible they represent eroded original vein quartz or quartzite.

As stated previously, the west arm of the Savant Lake conglomerate along Kashaweogama Lake is at least 54 km in length. The southern arm, which follows Savant Lake south (Bond 1977, 1979) into the Sturgeon Lake-Chevrier

Township area (Trowell 1977a,b) is traceable discontinuously for approximately 32 km. It is the author's belief that the conglomerate at Kashaweogama Lake faces south because graded sandstone-mudstone sequences immediately overlying the conglomerate in McCubbin Township (Bond 1977) face south, and because locally certain clast types are petrologically similar to and concentrated near possible proximal sources north of the underlying conglomerate (Bond 1977, p.43). Thus the Jutten Volcanic Sequence and conglomerate have a back-to-back relation in the Houghton-Hough Lakes area. This is a similar relation to that in McCubbin Township (Bond 1977). The former face northeast whereas the latter is unconformably deposited on the "Jutten Volcanics" and faces south. The Jutten Volcanic Sequence must have been overturned during an early period of deformation prior to deposition of the conglomerate.

Both conglomerates, along Kashaweogama Lake and Savant Lake respectively, are unconformably deposited on the Jutten Volcanic Sequence and may be stratigraphically equivalent. If so, a combined total strike-length of at least 80 km is indicated and marks a major stratigraphic break in the volcanism in the Savant Lake area (Figure 5, Chart A, back pocket). However, the two conglomerate units differ in the following ways:

1) the conglomerate at Savant Lake is overlain by a volcanic conglomerate that contains mainly volcanic clasts; no such unit is found associated with the conglomerate north of Kashaweogama Lake;
2) analyses of some of the granitoid clasts within the Kashaweogama Lake arm of the conglomerate show slightly higher concentrations of K_20 associated with greater normative potassium feldspar than those in the Savant Lake arm (Funk 1973, p.34) but this is probably just a reflection of variable provenance.

The conglomerate and related metasediments to the south in the Houghton-Hough Lakes area are believed by the author to be in fault contact with the Handy Lake Volcanic Sequence to the south; an apparent discordance between the trend of the conglomerate and the abutting formations of the Handy Lake Volcanic Sequence is evident along Kashaweogama Lake.

SANDSTONE AND MUDSTONE

The finer grained clastic metasediments along with their ferruginous metasediments form seven distinctive formations within the map-area. Except for the metasedimentary units north of Shoehorn Lake and the metasedimentary unit immediately south of the conglomerate on the south side of Fairchild Lake, the remaining metasedimentary formations within this group are intimately associated with the Handy Lake Volcanic Sequence. Clastic metasediments north of Shoehorn Lake are laterally continuous with the main metasedimentary sequence underlying the western part of Poisson and the southern part of McCubbin Townships (Bond 1977) and the northern part of Conant Township (Bond 1979). These sediments are herein referred to as the Savant Group (see Figure 5, Chart A, back pocket). The metasedimentary formation, south of the conglomerate on Fairchild Lake, is considered by the author to be related to the conglomerate which is unconformably deposited on the Jutten Volcanic Se-

quence north of Kashaweogama Lake; both of these are laterally continuous with the Savant Group. Top determinations were not obtained for the latter metasedimentary units. A contact between the conglomerate and overlying finer clastic metasediments exposed just south of Fairchild Lake indicates the two are sharply conformable but gave no clues as to their relationship.

Sandstone and mudstone units interbedded with ferruginous metasediments comprise formations which range in thickness from 90 to 600 m. Metasedimentary formations in the eastern part of the map-area are continuous with those mapped in Conant Township (Bond 1979); they disappear fairly abruptly at distances between 4 or 8 km west of the east boundary of the map-area. These metasediments comprise interbedded sandstone, mudstone, cherty siltstone, tuffaceous metasediments, and reworked pyroclastic deposits. These metasediments are thin bedded; bedding averages 2 to 5 cm, locally up to 15 cm in width. Apart from their abrupt westward terminations no general thinning trends were observed in the field. The metasediments south of the conglomerate near the west boundary of the map-area are very thinly bedded to laminated (3.0 to 0.63 cm) and are comprised of sandstone and siltstone.

Thin bedded alternating sandstone and mudstone sequences are most commonly observed but locally the sandstones and mudstones form separate units up to 3.7 m thick. The sandstone weathers grey to buff brown and is grey on the fresh surface. The mudstone weathers similar to the greywacke but locally displays tinges of green on both the weathered and fresh surfaces. The sandstone-mudstone sequences typically exhibit sharp bedding planes in all of the main metasedimentary formations which in general are in areas of greenschist facies metamorphic rank. Medium-grade (amphibolite) metamorphic conditions are present in the southern part of the map-area and there, thin discontinuous metasedimentary units are commonly garnetiferous and bedding is not readily apparent (Photo 13). The sandstones in the formations of the northern part of the area are generally massive, ungraded to locally graded (Photo 14) and primary sedimentary structures including scouring up to 12.7 cm in depth, crossbedding, and intraformational breccia (Photo 15) are only rarely exhibited. Minor sedimentary structures were most frequently observed in the vicinity of Shoehorn Lake; most of the metasediments show little evidence of current reworking. Nearly all top determinations in the metasedimentary formations interlayered with the volcanic sequence south of Kashaweogama Lake were found to face north suggesting that the entire upper volcanic (Handy Lake) sequence faces north.

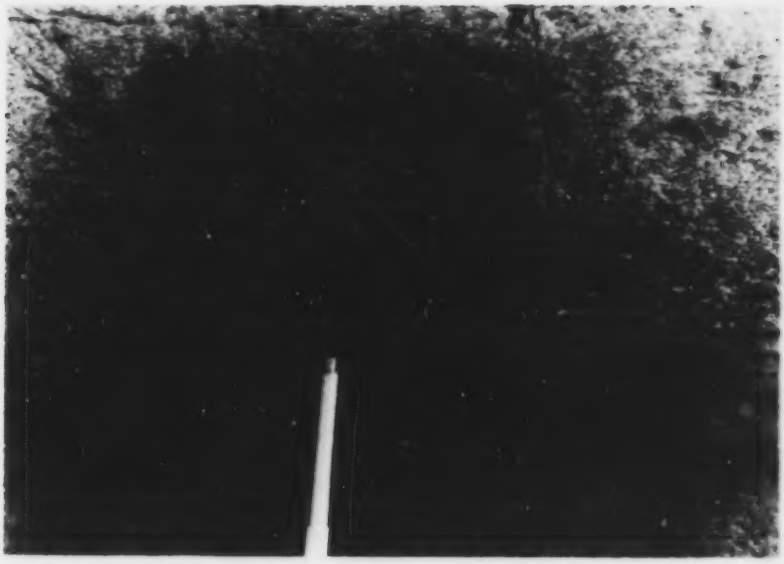
Modal analyses of typical sandstones are given in Table 6. According to the classification scheme of Young (1967) as used by Casshyap (1971), the sandstones are predominantly arkosic wacke and less commonly lithic arkosic wacke. In the field no attempt was made to subdivide the sandstones and they have been grouped together under map code 6a or 5b if in the presence of iron formation.

In thin section, the sandstones are bimodal being composed of two distinct sized fractions. Typically coarse-grained (greater than 0.2 mm) quartz, plagioclase, and rock fragments combined form 10 to 40 volume percent of the rocks; these coarse components are in a fine-grained (generally less than 0.06mm) matrix of quartz + plagioclase + indistinct rock fragments + biotite + chlorite ± muscovite ± calcite ± opaque minerals. The coarsest quartz, plagioclase, and

OGS 10,095

Photo 13–Massive to poorly bedded, extensively recrystallized, garnetiferous metasandstone in mixed volcanic unit just west of Evans Lake. Two thin amphibolitic, boudinaged, mafic volcanic lenses (ash beds?) are present near the bottom of the photo and parallel the bedding. Both the mafic layers and garnets weather positively; the garnets give the rock a knobby texture at the bottom of the photo. Pen in centre of photo is approximately 16 cm in length.

rock fragments are most evident in the sandstones in the vicinity of Shoehorn Lake. Quartz grains are generally more abundant than plagioclase grains. Both the coarse-grained quartz and fine-grained quartz are similar and form subangular to subrounded to locally well-rounded grains. Later tectonic deformation, especially within metasediments near the Kashaweogama Lake Fault zone, has produced strain and elongation of quartz in the plane of the foliation; elsewhere, many of the quartz grains remain unrecrystallized and locally only weakly fractured. No granulation is apparent around the margins of these latter grains. Recrystallized quartz pods containing an average of 5 to 10 subgrains are present and, although they may be lithic fragments, their shapes suggest they are recrystallized individual grains and are classified as such in the modal classification. The quartz grains as a whole are sharply defined against the finer grained matrix and are the most conspicuous component both in the field and in thin section. Plagioclase grains are also bimodal and are subangular, anhedral, generally untwinned grains. Where twinning is present it is generally hazy and ill-defined. The plagioclase is commonly altered to sericite and, compared to quartz, is more extensively recrystallized and commonly elongated in the plane of the foli-



DGS 10.096

Photo 14–Interbedded graded coarse sandstone and finely laminated siltstone from west shore of Shoehorn Lake - Part of pen is approximately 6 cm.

ation. Rock fragments, recognized by textural inhomogeneities such as change in grain size, or abundance and orientation of micaceous minerals, form from 0 to 15 percent of the coarse fraction and are much less abundant than quartz and plagioclase. Textural inhomogeneities indicative of lithic clasts are not easily recognized in thin section. Some of the coarser minerals of the matrix have been identified and counted separately in the modal analyses but finer grained parts are indistinguishable and remain grouped under simply "matrix". The sandstones appear massive in the field, but in thin section the short and stubby micaceous minerals are commonly subaligned to the bedding planes. Calcite is present in substantial amounts in the metasediments near Hough Lake; locally it may be an alteration product of plagioclase but generally it appears to be a metasomatic alteration mineral. The calcite is present as anhedral crystal aggregates that form hazy, discontinuous linear zones parallel to the fabric of the rock.

Metasediments of amphibolite facies metamorphic rank in the southeastern part of the map-area are commonly garnetiferous and in thin section are completely recrystallized to a fine-grained (0.06 to 0.08 mm), equigranular, mosaic of quartz + plagioclase + biotite ± garnet.

The mudstones are generally similar in composition to the sandstones but are distinctly finer grained (less than 0.03 mm). Mudstone is used as a general term characterizing all of the finer than sand-sized metasediments where the proportion of clay and silt is not known. Thin section examination indicates that most of the mudstones are composed of silt-sized clasts (0.004-0.06mm) and are

OGS 10,097

Photo 15–Intraformational breccia near the base of coarse sandstone bed with cuspate siltstone inclusions near the top of the same bed. From northwest shore of Shoehorn Lake. Pen is approximately 16 cm in length.

regarded to be mostly siltstones. Mudstone units are most abundant in the metasedimentary formations south of Hough Lake and just south of the conglomerate. In the field the mudstones commonly exhibit ill-defined laminations which in thin section reflect differences mainly in muscovite content. The mudstone units are comparatively richer in muscovite than the sandstones. Mudstone is locally very delicately interbedded with sandstone on an interval of 1 to 2 mm; the contacts between the sandstone and mudstone beds are sharply defined in both the field and thin sections.

Locally, in the metasedimentary formation south of Hough Lake there are thin (0.7 mm) shear zones that are evident only in thin section. The shears, marked by sericite and quartz and feldspar augen, display a slight rotation to the regional fabric. The shears are probably related to a fault known to exist in Conant Township (Bond 1979) that trends parallel to the eastern extension of these metasediments. No other major evidence to indicate the continuation of this fault within the Houghton-Hough Lakes area was observed in the field.

Based on the examination of a single thin section of arkosic wacke, the metasediments just south of the conglomerate south of Fairchild Lake appear to have the least amount of matrix and are composed of a combined total of 42 percent sand-sized quartz and plagioclase grains (analysis 415, Table 6). This arkosic wacke is strongly foliated due to cataclasis related to the Kashaweogama Lake Fault. Plagioclase grains are predominantly well rounded whereas the quartz grains are stretched and elongated parallel to the fabric.

TABLE 6 | MODAL ANALYSES OF METASEDIMENTARY ROCKS.

Sample	127	150	159	415
sand size feldspar (plagioclase)	6.0	4.7	11.4	15.2
sand size quartz	2.7	7.1	12.4	6.0
recrystallized qtz	2.3	1.4	11.0	22.1
rock fragments	1.2	0.4	6.0	
matrix (less than 0.06 mm)	32.9	58.7	16.2	23.9
silt size feldspar (plagioclase)	8.0	2.2	7.8	11.6
silt size quartz	32.5	7.9	7.4	5.2
chlorite	tr	2.2	3.0	0.2
biotite	8.4	12.4	13.4	3.3
muscovite	5.1		2.0	7.2
calcite	0.6	2.5	8.8	4.3
opaques	0.2	0.6	0.6	1.0
	99.9	100.1	100.0	100.0

(Matrix = indetermined mixture of quartz + plagioclase + muscovite ± biotite ± chlorite ± rock fragments)

127 — arkosic wacke from metasedimentary unit 762 metres south of Hough Lake
150 — arkosic wacke from metasedimentary unit 457 metres south of Fisher Lake
159 — lithic arkosic wacke from northwest shore of Shoehorn Lake
415 — arkosic wacke from metasedimentary unit south of conglomeratic unit on south side of Fairchild Lake

CHERTY SILTSTONES

Interbedded cherty siltstones are found in most of the metasedimentary sequences but are most abundant in the metasedimentary formation south of Hough Lake and in the thin metasedimentary unit just east of the bay leading south from Fairchild Lake to Moosolf Lake. These cherty metasediments are thinly bedded (0.63 to 4 cm) and constitute only about 5 percent of the metasediments as a whole. In the field they form positive-, white- to cream-weathering beds that are aphanitic and exhibit no internal laminations. These beds are typically cut by abundant blocky cross fractures, are massive, and except for bedding do not exhibit primary sedimentary structures. These rocks were not examined in thin section but they appear to be less quartz-rich than the previously described chert formation north of Kashaweogama Lake and may be composed of reworked felsic tuff debris.

TUFFACEOUS METASEDIMENTS

Interbedded reworked lapilli-tuff and tuff are most abundant in the metasediments in the vicinity of and just north of Shoehorn Lake. Where the fragments are coarse enough to be recognized in the field the fragments are observed to be all volcanic in origin; they are well rounded, distinct from ordinary lapilli-tuff deposits in which the clasts are lenticular to angular. Finer grained tuffaceous metasediments are commonly found interbedded with the above described cherty siltstones; they are typically chloritic, weathering dark green in the field. Bedding planes in these tuff deposits are diffuse. There is little difference in appearance between these tuffaceous metasediments and the reworked tuff deposits classified within the volcanic subdivisions; the former are associated with a dominantly sedimentary sequence whereas the latter are associated with a dominantly volcanic sequence.

Summary of Deposition of the Metasediments

The metasediments are associated with both of the volcanic sequences north and south of Kashaweogama Lake. The age relationships of these two sequences are not known, and no inferences can be made as to the relative time of deposition of their respective metasediments.

According to R.G. Walker (1975, p.153-156), the lack of grading and stratification in the conglomerate suggests it has been deposited as a debris flow which can occur in both subaerial and submarine environments. The fact that the conglomerate is marginal to and partly basal to the Savant Group of metasediments which are undoubtedly of turbidite (submarine) origin (Bond 1977, p.49) implies the conglomerate may also be submarine. This is reinforced by experimental modelling by M.A. Hampton who indicated subaqueous debris flows could in fact be transitional into and generate turbidity currents. He (1972, p.792) states:

> "Experiments indicate that transition from subaqueous debris flow to turbidity-current flow takes place by erosion of sediment from the front of the debris flow. Erosion occurs by shearing of sediment back along the surface of the front of the flow to a place where it is abruptly thrown into turbulent suspension. As sediment is thrown into suspension above the debris flow it mixes with water to form a dilute turbidity current."

It is the authors opinion that, the conglomerate is unconformably deposited on the Jutten Sequence, although with all due respect, this conglomerate does not contain a large amount of mafic volcanic clasts. This, along with the fact that the two types of trondhjemite clasts and the chert clasts are somewhat restricted in abundance to certain parts of the conglomerate, suggests its provenance varied substantially along strike.

Finer sandstone and mudstone formations are found only as local thin lenses in the lower part of the Handy Lake Volcanic Sequence but form substantial intraformational units near the top of the sequence as the intensity of volcanic activity diminished. The sandstone and mudstone exhibit thin, continuous beds which lack current-formed structures implying the sedimentary material has been transported fairly far from its source area before being deposited in rela-

tively quiet (deep water) conditions. Although the iron formation is intimately associated with the clastic metasediments,the sharp bedding plane boundaries between the two suggests that two sedimentary processes were operative. The iron formation appears to be chemically deposited with its deposition unrelated to the clastic sedimentation. Disseminated magnetite grains locally observed within the sandstone (clastic) part of the metasediments may have been incorporated during influx of the higher energy arenaceous debris but may also be authigenic, having precipitated out of small water pockets caught up within the sedimentary material.

METAMORPHOSED, PORPHYRITIC FELSIC TO INTERMEDIATE INTRUSIVE ROCKS

Quartz, quartz-feldspar, feldspar, and feldspar-quartz porphyritic rocks are predominantly found in the southwestern part of the map-area where they form a sill-like body centred between Houghton Lake and Patterson Lake. These porphyritic rocks are associated with mafic to intermediate and felsic to intermediate intrusive rocks. Thin porphyritic sills and dikes near Hough Lake are associated with intermediate and felsic metavolcanics of the Handy Lake Volcanic Sequence. Dimensions of these porphyritic bodies range from thin (0.60 m) dikes to the area attained by the large mass southeast of Houghton Lake which measures 6.0 km in length and averages 0.8 km in width.

Hand specimens of these rocks are light grey to dark grey to light pink and typically contain quartz and/or feldspar phenocrysts in a fine-grained to aphanitic, intermediate to felsic, massive matrix. Weathered surfaces are generally grey but pink colours are locally evident. Quartz phenocrysts vary from translucent grey to cloudy grey to locally blue on the weathered surface. Feldspar phenocrysts are invariably white to light grey on the same surface. These rocks are generally massive but locally have a vague foliation. In the field the quartz and feldspar phenocrysts are the most characteristic feature of these rocks. Although these two components are common to all of them, the porphyritic rocks actually appear fairly heterogeneous due to variation in the size of the phenocrysts, in the ratio of the abundance of quartz phenocrysts to feldspar phenocrysts, in the concentration or density of the phenocrysts, and in the amount of fracturing of the phenocrysts.

The porphyritic intrusive rocks closely resemble crystal tuffs of similar composition except the density of population of phenocrysts is lower and the phenocrysts are less severely fractured in the former. Generally, the porphyritic intrusive rocks are more massive and the phenocryst population is much coarser than exhibited in either extrusive porphyritic flows or crystal tuffs. The phenocrysts generally form 10 to 30 percent by volume of the rock.

The porphyritic intrusive rocks range in composition from andesite to rhyodacite. A chemical analysis of a typical quartz-feldspar porphyry from the large porphyritic mass between Patterson Lake and Houghton Lake is given in Table 5, Sample 24 and is plotted in Figure 3. Chemically and petrographically these rocks are similar to the "quartz-eye-bearing porphyroidal rocks" described by T.P. Hopwood (1976).

In the vicinity of Hough Lake mineral assemblages in these rocks are typically low to middle greenschist facies and include plagioclase + quartz + biotite + muscovite + chlorite + calcite ± opaque minerals ± epidote ± rare hornblende. Southeast of Houghton Lake, the large porphyritic mass has been metamorphosed to middle to upper greenschist facies and consists of plagioclase + quartz ± biotite ± chlorite (mostly retrograde) ± hornblende ± epidote (replacement of plagioclase) ± calcite ± rare microcline ± apatite ± allanite ± zircon ± opaque minerals. Plagioclase and quartz phenocrysts are randomly oriented although locally, vague alignment due either to primary flow alignment or later tectonic deformation is evident in thin section. Plagioclase is commonly more abundant than quartz. Twinned plagioclase phenocrysts for the most part were optically determined to be oligoclase. The plagioclase forms lath- to equant-shaped, subhedral to euhedral crystals whose maximum dimensions range from 1 to 5 mm but average 2 to 3 mm. In low- to medium-grade greenschist metamorphic facies conditions prevalent in the vicinity of Hough Lake, the plagioclase phenocrysts possess sharply defined boundaries, are commonly twinned, and locally altered to sericite and muscovite. The latter commonly have a preferred orientation along relict albite and pericline twins. In the southern mass southeast of Houghton Lake, where upper greenschist facies conditions exist, the margins of the plagioclase phenocrysts are ill-defined and blend into the more intensely recrystallized matrix. Also, the plagioclase is less commonly twinned and sericitic alteration is more severe. The matrix plagioclase is generally granular, untwinned, free of sericitic alteration, and difficult to distinguish from quartz; with increasing degree of recrystallization it tends to be more coarsely granular. Quartz phenocrysts vary from 2 to 5 mm and are subhedral to euhedral. In the vicinity of Hough Lake the quartz phenocrysts exhibit forms similar to that described by Hopwood (1976) including bipyramidal shapes, fracturing, embayments, subgrain growth, and variations in degree of recrystallization. In low to middle greenschist metamorphic conditions quartz phenocrysts are generally unstrained subhedral to euhedral and unrecrystallized. Granulation is however, developed along internal fractures that locally transect the phenocrysts and also around the margins of the phenocrysts. In upper greenschist metamorphic conditions, subgrain growth is more prominent and, like the feldspar phenocrysts, the margins of the quartz phenocrysts blend into the matrix. Biotite and chlorite form 7 to 20 percent of these rocks. Chlorite is intimately intergrown with and is metamorphically retrograded from biotite in the upper greenschist metamorphic facies. In the large porphyritic mass southeast of Houghton Lake, biotite is randomly oriented and commonly concentrated in clots which are subaligned reflecting the regional metamorphism. These mafic clots are easily weathered and appear as pits on the weathered surface. Hornblende forms up to 8 percent of these rocks; it forms randomly oriented, subhedral porphyroblasts that probably originated through contact metamorphism during granitic emplacement. Muscovite forms up to 15 percent of the porphyritic rocks metamorphosed under low to middle greenschist facies but is absent in higher metamorphic terrains. Calcite is particularly prominent in all of the porphyritic rocks near Hough Lake. Euhedral epidote is found as a common constituent replacing plagioclase in the porphyritic mass southeast of Houghton Lake. Apatite, allanite, zircon, and opaque minerals (pyrite and magnetite) are all accessory minerals. In one thin section a zeolite mineral believed to be stilbite was

found associated with a secondary quartz vein.

The origin of porphyritic rocks similar in texture to the porphyritic intrusive rocks in the Houghton-Hough Lakes area has always been in some dispute (Hopwood 1976). Textural inhomogeneities within the rocks may signify differences in intrusive history resulting from sequential, multiple intrusive events but can more aptly be regarded as differences in cooling history, volatile content (Hughes 1971), or depth of observed eroded surface. Certainly the porphyritic rocks do not necessarily have to have been intruded at the same time but their similarities in petrography suggest they may have stemmed from a common magmatic source. Evidence of multiple intrusion in the Houghton-Hough Lakes area is restricted to a single exposure approximately 0.5 km west of the group of islands in the southeast corner of Hough Lake where a younger quartz-feldspar porphyry dike cuts an older feldspar porphyry dike which is also discordant to the host pyroclastic rock. These dikes are too small to be indicated on the map other than by coding. The older feldspar porphyry is foliated and recrystallization of the feldspar phenocrysts has tended to mask their presence. Intrusive relationships for the porphyritic rocks are not widely abundant in the field and chilled margins were never seen. The only crosscutting contacts of the porphyritic intrusive rocks were found in the porphyritic dikes along the southeast shoreline of Hough Lake. The extensive porphyritic mass associated with the granitic intrusive rocks southeast of Houghton Lake is broadly concordant and no discordant contacts were observed in it. Mafic amphibolitized inclusions that may be either volcanic or intrusive are present within this sill-like mass and testify to its intrusive origin.

The porphyritic sill-like body in the southwest is spatially associated with and may be genetically related with the granitic intrusive rocks in this area. However, chemical analyses of the granitic and porphyritic rocks (Table 5, Samples 24, 25, 26) are significantly different and do not support this conclusion. According to the AFM plot of these samples (Figure 3), the porphyritic rock actually appears to be a later differentiate than the granitic intrusive rocks but field observations would discount this in that, in at least one exposure, porphyritic inclusions were found in a granitic dike that was injected into mafic to intermediate intrusive rocks (Photo 16). Furthermore, the porphyritic rocks are more extensively recrystallized than the granitic rocks suggesting a longer history of deformation. It is more likely that the porphyritic rocks are co-magmatic with the felsic to intermediate volcanic rocks of the Handy Lake Volcanic Sequence and this is supported by the AFM plot and the fact that the large porphyritic sill-like mass between Patterson Lake and Houghton Lake is laterally continuous with porphyritic to porphyroblastic intermediate volcanic rocks of extrusive origin.

The quartz-feldspar porphyry sill exposed on the southeast side of Hough Lake is distinctly pink; it is similar to and probably continuous with the porphyritic sills associated with the Conant Lake Intrusives on the south shore of Conant Lake (Bond 1979, p.46-50). In the Houghton-Hough Lakes area this porphyry has from 3 to 5 percent diseminated pyrite. A grab sample taken by the author and analyzed by the Geoscience Laboratories, Ontario Geological Survey disclosed 0.03 percent lead and approximately 0.01 percent molybdenum. This same pink porphyry transects felsic to intermediate porphyritic flows near the northeastern shore of Hough Lake just outside the east boundary of the map-

OGS 10.098

Photo 16–Intrusive breccia caused by injection of biotite trondhjemite phase into fine-grained, amphibolitized gabbro. Only vaguely discernible but outlined are inclusions of quartz-feldspar porphyry in the trondhjemite. Taken in intrusive complex 1 km southeast of Houghton Lake.

area. This mineralization is significant when one considers the spatial association of these porphyritic rocks to known massive sulphide deposits (Hopwood 1976). Copper, lead, and silver mineralization was also observed along a fracture in the extensive porphyritic sill southeast of Houghton Lake. The fact that the pink porphyritic rocks are found in discordant relations unlike the grey porphyritic rocks which are roughly concordant suggests they may be younger than the latter and genetically related to the granitic intrusive rocks.

MAFIC TO INTERMEDIATE INTRUSIVE ROCKS

Two extensive, sill-like lenses of mafic to intermediate intrusive rocks are present in the southwestern part of the map-area. Several smaller satellite lenses undoubtedly related to the two main sills are present as inclusions within the adjacent granitoid intrusive rocks. The two main sills extend from just east of Houghton Creek westward to the area south of Houghton Lake and west to the border of the map-area. Subsequent mapping by J.R. Trusler (1975) indicates the presence of a large mafic to intermediate stock west of the southwestern part

TABLE 7 FIELD CLASSIFICATION OF MAFIC TO INTERMEDIATE INTRUSIVE ROCKS.

TERMINOLOGY	COLOUR INDEX (% Mafic Minerals)	QUARTZ CONTENT (Volume Percent)
Quartz diorite to biotite-hornblende trondhjemite	20-25	generally 15 to 20
Quartz diorite	25-40	10-15
Diorite	20-40	< 10
Quartz Gabbro	> 40	> 10
Gabbro	> 40	< 10

of the Houghton-Hough Lakes area. These two mafic sills are in fact apophyses that extend eastward from this main stock which is approximately 3.4 km in diameter. Within the limits of the present survey these sills are 12.5 km in length and vary in thickness from 150 to 1100 m but average 450 m. The northern sill is the more extensive of the two. Except for the western part of the more northerly sill which appears to be slightly deflected by the granitic intrusive rocks, the two sills are broadly concordant to stratigraphy.

The mafic to intermediate intrusive sills are composed predominantly of quartz diorite, and less abundant gabbro; locally these two types grade imperceptibly into phases of diorite, mafic biotite-hornblende trondhjemite, and rare quartz gabbro. Table 7 summarizes the parameters (colour index and quartz content) used in distinguishing these phases in the field. Due to the gradational contacts between many of the phases and the difficulty in distinguishing the quartz content because of the fine grain size, it was necessary to code the maps according to a range in composition. Determination of the anorthite content of the plagioclase is necessary for final classification of these rocks (Ayres 1972) but the heavily sericitized nature of some of the thin sections precluded any possibility of determining some of these compositions. Except for areas of gabbro, most of the rocks in the sill are considered to be predominantly quartz diorite. This is substantiated by modal analyses of typical samples given in Table 8. Those plagioclase crystals exhibiting twinning were found to be mostly in the range An_{34}-An_{44} (andesine) but locally individual grains indicated compositions of An_{56} (labradorite) and An_{28}-An_{30} (oligoclase). This latter composition may be metamorphically derived. A chemical analysis of a fine-grained quartz diorite is given in Table 5, analysis 23 and plotted in Figure 3. The chemical analysis indicated a normative plagioclase composition of An_{43}.

In the field these rocks weather from dark grey to dark green (green varieties are generally gabbroic in composition) and are usually dark grey on the fresh surface. Grain size is commonly medium to fine grained (approximately 2 mm); locally coarse-grained (4 to 5 mm) phases are present. In the eastern part (be-

TABLE 8 MODAL ANALYSES OF TYPICAL QUARTZ DIORITES.

Sample Number	190	252	305	3127	3137
Plagioclase	49	46	52	51	45.5
Hornblende	24	29	29	24	20.8
Quartz	11	12	11	15	22.1
Biotite	13	6	7		8.6
Chlorite	1	1		6	1.0
Epidote	< 1	1	< 1	2	1.1
Apatite	< 1	1	< 1	< 1	0.2
Sphene	1				
Opaque (mainly magnetite)	1	4	1	2	0.5
Potassium feldspar					0.2
Number of points counted	500	500	500	500	600

tween Houghton Creek and the small lake 4 km west of Evans Lake along the south boundary of the map-area) the rocks are fine grained (1 mm or less) and difficult to distinguish from extrusive rocks of similar composition which they are on strike with. This fine-grained part is considered to be a subvolcanic phase that may grade into extrusive rocks of similar composition. These rocks are generally massive to locally porphyritic; in places the amphibole is locally foliated to lineated subparallel to the overall trend of the sills. Locally jointing is prominent and is transverse to the trend of the sills. Extensive granitic dikes have been injected into the sills; the margins are commonly a composite mixture of granitoid and mafic to intermediate intrusive rocks and their positions have been approximated according to the more abundant component. The abundant granitic material injected within the sills and the low magnetic profiles exhibited by the sills (ODM-GSC 1961) suggests they do not penetrate to any great depth but instead are closely underlain by granitic material. Except for the eastern, fine-grained marginal phases, no possible chilled zones were observed.

The typical mineral assemblages in these rocks are plagioclase + hornblende ± actinolite ± quartz ± biotite (mostly retrograde) ± retrograde chlorite ± epidote ± apatite ± sphene ± opaque minerals (mainly magnetite) ± muscovite. Plagioclase, especially in those rocks near Patterson Lake, is heavily sericitized locally altered to epidote and is untwinned. Farther west the sericitic alteration is patchy to absent and the plagioclase (2 to 3 mm) exhibits prominent albite and locally pericline twinning indicating compositions of andesine in most sections. Locally calcic oligoclase (An_{28-30}), which may be metamorphic, and sodic labradorite (An_{50-57}) are present in the more leucocratic and melanocratic varieties respectively. In the eastern fine-grained margin, the plagioclase is more finely recrystallized (less than 0.5 mm) in the matrix but locally also forms phenocrysts (2.0 mm) and porphyroblasts. The amphibole is generally hornblende

but actinolite is also fairly common in the eastern fine-grained margin. Hornblende varies from less than 1 mm to 5 mm, averaging 2.0 mm; it commonly forms poikiloblastic, randomly oriented, subhedral, prismatic crystals containing inclusions of quartz. Actinolite is similar except it tends to form fan-shaped, non-poikiloblastic, subhedral crystals that exhibit a more subdued pleochroism. Quartz is invariably interstitial, forming in pockets (1.5 to 2.0 mm but locally up to 3.0 mm); it is anhedral to rarely subhedral and is locally fractured. Generally the quartz is only slightly recrystallized and is free of inclusions. Biotite forms equant anhedral crystals which, except for sphene, are free of inclusions. The biotite is generally retrograde from amphibole. Chlorite (0.1 to 0.2 mm) generally exhibits anomalous blue birefringence typical of penninite; it is intergrown with and is a product of retrograde metamorphism of biotite. The porphyroblastic amphibole within the mafic sills probably developed as a contact metamorphic effect produced by later intrusion of the batholithic complex. The retrograde metamorphism (in the south part of the map-area) is regarded to be the latest metamorphic event. Epidote is generally an alteration product of plagioclase. Apatite and sphene are present along with magnetite as accessories.

The quartz content and colour index vary chaotically throughout the sills with the result that, because of their heterogeneous appearance, traceable marker units are nonexistent. The only real distinguishable marker unit within the sill complex occurs in the more northern sill midway between Patterson Lake and Houghton Lake where a large area of metagabbro is exposed partly along the southern margin. It is not known if this metagabbro phase differentiated in situ from the rest of the sill or merely represents a sequential intrusive phase. Trusler (1975) indicated the large intrusive body just west of the map-area to which these sills are adjoined is similarly partly differentiated. No igneous layering was apparent within these intrusions in the field.

The mafic to intermediate intrusive sills are closely associated with extrusive rocks of similar composition and may represent original feeder zones to the volcanic rocks. No relative age relationships were noted in the field but, the presence of small mafic inclusions within the sill and the fact that the sill-rocks are less extensively recrystallized than the mafic volcanic rocks suggests the sills are not coeval with the volcanic rocks but are later intrusions.

Peridotite occurs only as inclusions within the Fairchild Lake Intrusion. These ultramafic pods are probably related to the only other ultramafic body known to occur in the Savant Lake area which is reported by Hudec (1965) to be a dunite body at the south side of Armit Lake approximately 1.6 km north of the northwest corner of the map-area. The peridotite weathers rusty brown with local hues of red and green and is dark grey-black on the fresh surface. Locally the latter also has tinges of green due to serpentine alteration. The peridotite does form whole outcrops that are not highly injected by the Fairchild Lake Intrusion. One of the exposures on a small island just southwest of the rapids in the Marchington River at the east end of Fairchild Lake, was observed to have a polygonal structure similar to the structure described by D.R. Pyke (1975, p.12) in ultramafic rocks of extrusive origin and it is possible these peridotite zones were originally extrusive.

FELSIC TO INTERMEDIATE INTRUSIVE ROCKS

Three separate felsic to intermediate plutonic complexes have intruded the Houghton-Hough Lakes area but, due to their wide spatial separation and the fact that the three appear to be recrystallized or metamorphically altered to the same extent, no relative age relationships are known.

Fairchild Lake Intrusion

The Fairchild Lake Intrusion in the northwestern part of the map-area is part of a large batholith extending westward out of the map-area for approximately 16 km. This batholith is at the south margin of and is part of the southern granitoid domain of the English River Subprovince (Breaks and Bond 1976). At Fairchild Lake the intrusion is composed of weakly porphyritic granodiorite to quartz monzonite that has been complexly cataclastically deformed by faulting. The intrusion weathers white to grey to weakly pink and is light grey on the fresh surface.

In the field the majority of the intrusive rocks are weakly deformed and are characteristically comprised of phenocrysts of microcline with an augen structure in a gneissose, well-foliated matrix. Foliation intensity varies throughout the intrusion from generally well foliated to strongly cataclastic especially along the southern margin but is locally only weakly foliated near the central part. The deformed microcline phenocrysts vary from 1 to 3 cm and locally up to 5 cm; a few exhibit sigmoidal fold structures. On stained surfaces potassium feldspar phenocrysts can be recognized elongated as much as 20:1 and appear as thin lenticles or ribbons. Mafic (biotite) mineral trains and elongated quartz ribbons of similar or greater dimensions complement the elongated potassium feldspar giving the rock a gneissic texture. The size of the microcline phenocrysts is not substantially larger than those crystals that constitute the matrix; this, along with the fact that both are similarly elongated, makes it hard to distinguish the phenocrysts in the field. Throughout the intrusive complex but most abundant along its southern margin, alternating mafic and felsic bands are present. The banding may, in part, reflect hybrid zones but is mainly due to differences in intensity of deformation resulting in alternate layering of weakly cataclastic (felsic) and complementary protomylonitic (Spry 1969) (mafic) bands. The felsic bands, changed least from their former undeformed state, are composed mainly of medium- to coarse-grained plagioclase, quartz, microcline, and minor biotite whereas the mafic(protomylonitic) bands are finely granulated into a mixture of predominantly sericite, quartz, and plagioclase. The protomylonitic bands range in width from several centimetres to approximately 60 cm and are fairly continuous across the limited dimensions of single exposures. Pseudotachylite is locally present along fractures that cut the fabric of both the weakly cataclastic and protomylonitic bands. Inclusions of mafic volcanic rocks are fairly abundant and are generally concordant to the fabric of the rock. Minor occurrences of peridotite and one xenolith of quartz-feldspar porphyry is also present as inclusions. Coarse-grained to pegmatitic quartz monzonite is the latest phase and is present as dikes, sills, and small isolated pods within the intrusion. Most of these

pegmatoid zones are also cataclastically deformed and most commonly strike northeast or southwest. Some of the dikes, however, are massive, possess sharp contacts, and appear relatively undeformed suggesting that some of the magmatic activity postdates the faulting event. The isolated pegmatitic pods may have crystallized in situ from small volatile-rich pockets.

As indicated in the section on structure, there are three directions of cataclastic movement confined within the restraints of the Fairchild Lake Intrusion. No relationships among these three directions were noted in the field except in one place where a banded, weakly cataclastic zone and complementary protomylonitic zone are cut at high angle by a fairly strong foliation suggesting more than one age of deformation. Both the mafic volcanic rocks on the northeastern margin and the conglomerate and associated metasediments on the southern margin are strongly sheared and kinked.

In thin section the weakly cataclastic parts are not extensively metamorphosed or recrystallized and exhibit a well formed tectonic (fine) breccia as defined by A. Spry (1969, p.229). In these zones the most characteristic texture is that of quartz which is highly elongated forming a ribbon-like network structure that is evident in the field. Both G. Voll (1960) and M.W. Higgins (1971) cite quartz as being one of the first minerals to be affected during deformation and cataclasis. The quartz ribbons show no evidence of granulation along their margins and consist of anhedral subgrains of quartz. Plagioclase (oligoclase) forms anhedral, roughly equidimensional, irregularly outlined to sutured plates (1 to 2 mm) that are generally untwinned to locally twinned and are well fractured. Generally, the plagioclase is only lightly altered to sericite. Potassium feldspar is anhedral, mixed with plagioclase (this accounts for the diffuse nature of the stain on some surfaces) and these crystals are elongated into augen. Due to the anhedral nature and intergrowth with anhedral plagioclase it is not known if these potassic-appearing crystals represent augen phenocrysts or whether the microcline is, in part, metasomatic and introduced into previously dominantly plagioclase-rich augen zones. The presence of the in situ pods of pegmatite suggests that the microcline is original. Biotite is present as randomly oriented plates that form in long trains or linear zones that are 4 to 6 mm in length and 0.7 mm in width. Chlorite is locally retrograde from the biotite. Epidote, allanite, minor sphene, and calcite are accessory minerals. The more mafic-appearing protomylonitic zones exhibit well formed mortar textures in which larger strained crystals are surrounded by finer grained highly sericitized matrix that forms approximately 30 to 50 percent by volume of the rock. Locally thin mylonitic (Spry 1969, p.229) shear zones are present within the protomylonitic part. Pseudotachylite where present in thin section is roughly opaque and marked on the edges by abundant sericite with associated magnetite grains.

Mineral segregation of the felsic and mafic (micaceous) components into separate layers is due to the fact that different minerals having different mechanical properties behave differently during deformation (Spry 1969, p.237). As reviewed by Spry (1969, p.237) the more ductile minerals (micas) are "smeared out into intensely sheared layers while the more brittle minerals (feldspar and quartz) are segregated into layers between the shears".

Dickson Lake Pluton

The granitoid intrusion north of Kashaweogama Lake is part of the Dickson Lake Pluton, the vast bulk of which is north of the map-area. Recent geological reconnaissance (Breaks and Bond 1976) indicates this pluton is elliptical and is 9 km in length and 4.4 km in width. The long axis strikes approximately northwest. Dickson Lake lying near the east-central boundary of the pluton is 3.2 km north of the 7th base line. The Dickson Lake Pluton has been emplaced in mafic metavolcanics which wrap around the margin of the intrusion.

In the field the intrusion is massive and consists of fine- to medium-grained granodiorite. Locally near the margin of the intrusion just north of Kashaweogama Lake the rock is foliated to very weakly cataclastic. Locally the intrusion varies in composition from granodiorite to quartz monzonite and north, outside the map-area, the southwestern margin of the intrusion is trondhjemitic. Grain size is uniform throughout the pluton. Minor leucocratic aplite and rare pegmatite (north of the map-area) that are both quartz monzonite in composition occur as thin dikes near the margin of the pluton. The Dickson Lake Pluton is bordered by mafic metavolcanics of the Jutten Sequence around most of its margin but in the north is in contact with gneissose granitic rocks of the English River Subprovince. Although the pluton is in contact with mafic metavolcanics throughout most of its margin, there are no inclusions of mafic metavolcanics within it. The margin of the pluton is generally sharp and smooth; the contact of the intrusion is not interrupted by apophyses injected into the host mafic volcanic rocks.

Plagioclase forms 45 to 52 percent of the rock. It is euhedral and forms crystals up to 4.0 mm but averaging 1.5 to 2.0 mm. The plagioclase is randomly oriented and commonly exhibits complex oscillatory zoning. In some sections the plagioclase is heavily altered to sericite and where zoning is prominent, this alteration is selective. No twinning of the plagioclase is apparent in thin section. Quartz makes up 25 percent of the rock, is anhedral to locally subhedral, and is interstitial. The quartz is not intensely recrystallized being composed of fairly coarse subgrains (0.3 to 0.4 mm). Microcline, constituting 10 to 15 percent of the volume of the rock is anhedral, interstitial to the plagioclase, and is locally perthitic. Locally the microcline forms coarse patches (4 mm) that are optically continuous. Randomly oriented plagioclase crystals are found arrested in these patches. Biotite forms 5 to 8 percent and is present as anhedral plates. Sphene, apatite, and opaque minerals are accessories. In the weakly cataclastic margin the plagioclase locally exhibits deformation (polysynthetic) twinning and is locally granulated along the margins. The quartz is elongated forming a ribbon-like structure as in the Fairchild Lake Intrusion. Again, no granulation is present along margins of the quartz ribbons. Microcline is also elongated. Essentially most of the pluton is very weakly recrystallized to locally unrecrystallized; the only extreme deformation has occurred near the margins and it is not known if this originated during intrusion or during later fault deformation along Kashaweogama Lake.

In accordance with the criteria set forth by A.F. Buddington (1959) including (1) the presence of aplite and its restriction to the margins, (2) the absence of foliation throughout most of the intrusion, (3) the small nature of the pluton

(approximately 40 km^2), and (4) the emplacement being to some extent tectonically controlled at the margin of the English River Subprovince and the Wabigoon Subprovince, the Dickson Lake Pluton is probably epizonal in origin.

Hough Lake Stock

The Hough Lake Stock has intruded the central part of the Houghton-Hough Lakes area just west of Exploration Lake. Roughly diamond-shaped, the stock is elongated in an east-west, approximately concordant direction and has maximum dimensions of 4.4 km in the concordant direction and 1.6 km perpendicular to this direction. The stock underlies an area of approximately 5 square km. It is homogeneous in texture and composition and is composed of massive, medium- to coarse-grained biotite to locally hornblende-biotite trondhjemite. The trondhjemite weathers grey to white and is light grey on the fresh surface. Grain size averages approximately 4 to 5 mm throughout except in the southwest where it grades into fine- to medium-grained rocks of similar composition. Except for a thin inclusion of quartz-feldspar porphyry near the eastern margin of the stock near Exploration Lake, the stock is generally free of inclusions. Plagioclase, quartz, and biotite are the main minerals in the stock and are easily distinguished.

In thin section the rock is composed in order of decreasing abundance: plagioclase + quartz + biotite ± chlorite ± hornblende ± epidote ± allanite ± sphene ± opaques ± tourmaline. Plagioclase forms approximately 50 percent of the rock; the lath-shaped crystals are subhedral to locally euhedral, randomly oriented, and are 3 to 4 mm along their long axis. Although the plagioclase is not heavily sericitized, twinning is poorly preserved to absent. In places the plagioclase exhibits a sieve-like texture due to abundant inclusions of tiny granules of myrmekitic quartz. In one thin section, the plagioclase was determined to be oligoclase (An_{20}). Quartz is interstitial, weathers moderately dark grey, and forms patches 3 or 4 mm across. The quartz has been weakly recrystallized into subgrains averaging 0.3 mm and forms approximately 35 percent of the rock. Biotite constitutes 8 to 10 percent of the rock and forms aggregate clots 5 to 7 mm across. The clots are distinct as they weather easily in relation to plagioclase and quartz giving the surface a pitted texture. Chlorite locally forms subhedral prismatic crystals, is locally acicular and intergrown with biotite, and makes up only about 2 to 3 percent of the volume of the rock. Blue-green birefringent hornblende forms randomly oriented, very small, subhedral, prismatic crystals. The hornblende forms less than 1 or 2 percent of the rock and is not evident in the field. Epidote is found replacing plagioclase and is also associated with the clots. Minor allanite, sphene, tourmaline, and opaque minerals are accessory minerals. In the southwest the coarse patches of quartz are still evident but the remaining part of the rock is finely recrystallized. Although the stock adjoins the main part of the intrusive complex in the southwest of the map-area, there is no evidence to indicate it is in any way related to it. Chemical analysis of the finer grained border phase of the Hough Lake Stock is given in Table 5, analysis 26 and is plotted on the AFM plot in Figure 3. A chemical analysis of a fine- to medium-grained trondhjemite from the intrusive complex 1.0 km west of Patterson Lake,

Table 5, analysis 25 plots more towards the alkalic end of the AFM plot (Figure 3) suggesting it is a later differentiate. If the Hough Lake Stock is genetically related to the batholith it may represent an early phase. The massive, coarse-grained, allotriomorphic texture suggests the magma was fairly rich in volatile components thus lowering the crystallization temperature and permitting a more lengthy period of crystallization. The smooth, regular outline of the stock, the lack of apophysal dikes into the surrounding rocks, and the lack of abundant xenoliths indicate the magma crystallized at a depth where volatiles were not allowed to escape. These features indicate the stock was not emplaced by a stoping method (Nystuen 1975) and that probably the stock rose as a single diapiric mass.

Southwest Batholithic Complex

The southwestern part of the map-area is underlain by several phases of granitic rocks. These intrusions appear to be part of a large batholithic complex indicated by Davies *et al.* (1970) and R.B. Barlow *et al.* (1975) to underlie the area south from the map-area to the Sturgeon Lake Volcanic Belt. These intrusive phases in the southwestern part of the map-area are fine to medium grained, weather similarly, and are not readily distinguishable in the field. However, from thin section examination and potassium staining, several distinctive phases are apparent and are described below.

Granodiorite and Quartz Monzonite

West of and adjoining the Hough Lake Stock and underlying the area between Patterson Lake and Houghton Lake there is a large granitoid mass that ranges in composition from trondhjemite (mainly along the western and southern margins) to predominantly granodiorite to quartz monzonite (mainly in the north and central parts). These phases are not easily distinguishable in the field in that they both weather grey to locally pink and are grey to pink on the fresh surface. These rocks are generally massive to weakly foliated.

In thin section the rocks are extensively recrystallized, composed of plagioclase (albite-oligoclase) + quartz ± microcline + biotite + epidote ± chlorite ± hornblende ± muscovite ± allanite ± sphene ± calcite. Plagioclase (2 to 3 mm) is subhedral to locally euhedral, commonly heavily sericitized, partly recrystallized, locally exhibits oscillatory zoning, and is pink on the weathered surface. Quartz is extensively recrystallized into granules (less than 0.5 mm) and is interstitial along with microcline. Locally quartz is myrmekitic, intergrown with plagioclase but the texture is not evident due to recrystallization. Hornblende is locally present only in the western (predominantly trondhjemitic to granodioritic) part of this intrusion. This intrusive body west of the Hough Lake Stock is more extensively recrystallized than the other granitoid phases in the Houghton-Hough Lakes map-area. Due to the greater degree of recrystallization, individual minerals such as plagioclase, quartz, and microcline have diffuse bounda-

ries and are not easily distinguishable in hand specimen. For comparison with the Hough Lake Stock, a chemical analysis of the southern, fine-grained trondhjemitic border phase is given in Table 5, analysis 25, and is plotted on the AFM diagram (Figure 3).

Biotite and Hornblende-Biotite Trondhjemite, and Granodiorite

The large area of granitoid rocks south from the above-described intrusive phase and the Hough Lake Stock is less potassic and composed of biotite and hornblende-biotite trondhjemite to granodiorite. These rocks differ little from the above-described rocks except they are less extensively recrystallized and hornblende-bearing phases are more prominent. In the field the hornblende is hard to distinguish from biotite but may confidently be suspected in rocks whose colour index is greater than 10 or 12 percent. Hornblende phases are most abundant in the area south of Houghton Lake. The northern margin of the intrusion is locally migmatitic due, in part, to abundant hybridized inclusions. Numerous inclusions of mafic, intermediate, and felsic metavolcanics, quartz diorite (see Photo 16), and quartz-feldspar porphyry (see Photo 16) are present throughout the intrusion.

Only one thin section of the hornblende-biotite trondhjemite was examined. Plagioclase is subhedral, randomly oriented, unaltered, and locally exhibits polysynthetic twinning. Quartz is present as fairly coarse subgrains forming patches up to 2 or 3 mm. Biotite forms broad anhedral plates whereas dark green hornblende is present as randomly oriented, subhedral to anhedral prismatic crystals.

Cenozoic

QUATERNARY

Pleistocene

During Pleistocene time, the map-area was covered by several ice masses the last being the Wisconsinan Sheet which began retreating between 14,000 and 13,000 years ago (Prest 1970). According to V.K. Prest (1970, p.720) the margin of ice had retreated and lay very near to the Houghton-Hough Lakes map-area sometime between 10,600 and 10,300 years ago. The area south from the margin was covered by glacial Lake Agassiz. A minor re-advance of the ice front occurred between 10,300 and 10,000 years ago. From 10,000 to 9,500 years ago the ice retreated for the last time. During this time the ice margin remained in contact with Lake Agassiz which also retreated to the northeast. Lake Agassiz covered the Houghton-Hough Lakes area at this time and remained long enough to modify the glacial deposits. Glacial striae are best exposed on lakeshore exposures and indicate the last direction of ice movement to have a relatively consistent trend of S28W to S30W.

Several lakes in the southern part of the map-area and those lakes adjacent to the eskers (e.g. Island and Shoehorn Lakes) conform to the direction of the last ice movement. Except for Kashaweogama Lake which is positioned along a fault zone, most of the remaining lakes do not reflect the trend of the underlying lithologies.

GLACIAL TILL

The Houghton-Hough Lakes area is covered by a thin, fairly continuous blanket of glacial till. Locally, in the vicinity of the two eskers the Pleistocene deposits are much thicker. Limited diamond drilling in the area indicates the till deposits vary in thickness from 1 m to 10 m although the latter probably does not represent the maximum. In general the bedrock in the map-area is not sufficiently exposed to indicate underlying lithologic trends on aerial photographs. Glacial till is generally sandy in texture; it is unsorted, composed of pebbles and cobbles of various lithologies some of which reflect the compositions of the nearby underlying lithologies.

S.C. Zoltai (1965a) reported the till in the vicinity of Savant Lake to be composed of 90 percent sand-sized particles, 10 percent silt, and negligible clay. Exposed glacial till is found locally at some of the roadcuts on Highway 599 but elsewhere is most commonly observed as thin layers lapping onto the edges of outcrop.

Recognizable geomorphological forms resulting from the glaciation are rare and the present surface relief is fairly flat. Vague, discontinuous, north-northeast-trending fluting is found 1.6 km west-southwest of Fisher Lake, 183 m west of Moosolf Lake, just southeast of Hough Lake, and locally in the area west of Patterson Lake and south of Houghton Lake. Drumlinoid forms are locally associated with the fluting but are ill-defined due to reworking by the erosional affects of Lake Agassiz.

GLACIOFLUVIAL DEPOSITS

Glaciofluvial deposits form two eskers within the map-area, which trend parallel to the direction of ice flow. Originating north of the map-area, their sinuous courses are interrupted at several places between Pashkokogan Lake (13.5 km to the north of the map-area) and Kashaweogama Lake (Zoltai 1965b). Within the map-area the two eskers are first encountered just south of Kashaweogama Lake; southwards from there they are discontinuous and end completely within the limits of the map-area. The eskers vary in breadth from 75 to 150 m at their base and attain a maximum height of approximately 30 to 35 m. The esker between Shoehorn and Hough Lakes is highest at a point just south of these two lakes whereas the more westerly esker is highest in the area southwest of Houghton Lake. At these points of highest relief the sides are fairly steep whereas in areas of outwash they are more gentle. Both of the eskers locally have braided courses and are, in places such as just south of Shoehorn Lake,

marked by kettle lakes. The eskers are composed of sandy till and large boulders. No bedding of any nature was exposed on the eskers proper. Both eskers are marked by deltaic build-up of finer sandy fan deposits near their southern terminals and locally along their flanks. These deposits are composed of well bedded, well sorted sandy deposits with rare pebbles and cobbles. The esker deltas form gently sloping, smooth profiles. The crests of the eskers are hummocky composed of mainly coarse boulders, the fine-grained matrix having been washed away to form the esker delta deposits. The lag concentrate of boulders on their crests has undoubtedly inhibited further erosion of the eskers. The discontinuous nature of the eskers and esker outwash deposits along the flanks of the eskers may have resulted from wave-washing action of Lake Agassiz. No glaciolacustrine deposits were observed in the map-area.

Recent

Redistribution of the Pleistocene deposits is locally evident in the map-area. Sand, silt, and gravel deposited locally by streams and organic build up of mud deposits associated with muskeg swamps constitute this material. Well sorted sand deposits are also found in beach accumulations along lakeshores and have been concentrated through wave action. The largest continuous muskeg swamp is 3.2 km west of Shoehorn Lake. The muskegs in the northern part of the map-area are commonly wet whereas, in the south, the muskegs are generally dry. This is due to the higher relief in the south and consequently better drainage.

CORRELATION OF GEOLOGY WITH AEROMAGNETIC DATA

The aeromagnetic expression of the map-area is given on Aeromagnetic Map 1119G, Kashaweogama Lake Sheet, (ODM-GSC 1961) published jointly by the Ontario Department of Mines and the Geological Survey of Canada. The survey was flown in 1961 and the map was issued at a scale of 1:63 640.

Two intense anomalously high zones that reflect underlying iron formation-bearing metasediments are within and near the map-area and these tend to mask all magnetic trends in the northern part of the survey area. Covering the entire northeast quarter of the map-area there is an anomalous zone whose intensity ranges up to a high of 80,000 gammas. A second anomaly with a maximum intensity of 66,000 gammas is situated just north of the northwestern corner of the map-area. Because of the intensity and extent of these two zones, background magnetic intensities cannot be correlated to the actual pattern of the underlying lithologies north of a line extending from the north shore of Houghton Lake to Island Lake, through to Willow Lake.

North of Shoehorn and Hough Lakes the large high anomaly is composed of a series of small anomalous peaks which in fact can be correlated to the underlying thin iron formation-bearing units. These small anomalous peaks trend east-west similar to the trend of their associated metasedimentary units. Near Fisher

Lake continuation of the two southern iron formation-bearing units and disappearance of the northern unit is apparent by the presence of two magnetic peaks near the western part of the large anomalous zone and by the absence of a peak associated with the area directly west of Fisher Lake. The maximum intensity (80,000 gamma) is situated in the extreme northeastern corner of the map-area over a large iron formation prospect (Shklanka 1968, p.396); this is the highest anomalous zone in the Savant Lake area and this, along with the fact that the gamma contour interval is closely spaced, suggests the iron formation there to be the best quality available in the region. Emphasis of company work (Bond 1977, p.60-66) and field observations by the author support this interpretation.

Magnetic trends over the southern part of the map-area concur fairly closely with the distribution and pattern of the underlying lithologies. The intermediate to mafic intrusive sills south of Houghton Lake produce correlative positive linear anomalies but these are only about 50 to 100 gammas above background and indicate the sills do not extend to any great depths. Adjacent to these linear zones there are complementary magnetic depressions associated with granitic intrusions. The remainder of the southern part of the area is relatively flat owing to the lack of magnetite-bearing lithologies. Even so, the vague trends outlined can be correlated to the trend of the underlying metavolcanics and metasediments. The mafic metavolcanic sequence approximately 1.5 km south of Exploration Lake produces a negative anomaly which suggests these rocks also do not continue to any great depth but instead are underlain by granitic intrusions. This interpretation is supported by the extensive recrystallization of nearby felsic to intermediate metavolcanics. The lense of iron formation-bearing metasediments just south of Hough Lake forms a distinctive magnetic expression 1,000 gammas above a background value of approximately 60,500 gammas.

METAMORPHISM AND ALTERATION

The Houghton-Hough area has undergone several periods of metamorphism. The entire area has been regionally metamorphosed. North of Kashaweogama Lake the mafic volcanic sequence and associated chert-iron-silicate formation have been metamorphosed to predominantly amphibolite facies or medium-grade metamorphic conditions (Winkler 1974). South from Kashaweogama Lake to just south of Island Lake the area has been regionally metamorphosed to greenschist facies or low grade metamorphic conditions (Winkler 1974). South from a line running approximately 300 to 400 m north of and parallel to the contact of the intrusive complex in the southwest, extending past Exploration Lake to just north of Evans Lake the area has been regionally metamorphosed to medium- (amphibolite) grade metamorphic conditions. Locally, south of this line there are isolated occurrences of staurolite, sillimanite, and andalusite indicative of medium-grade metamorphic conditions. In the Extreme southeast corner of the map-area the rare presence of kyanite indicates at least upper medium-grade metamorphic conditions were reached. Most of these rocks are completely recrystallized to a granoblastic assemblage of quartz + plagioclase + biotite ± muscovite which due to lack of index minerals cannot easily be categorized into a metamorphic grade. The total absence of prograded chlorite in

both muscovite-bearing and in non-muscovitic assemblages in this part of the map-area is indicative of medium-grade metamorphic conditions (Winkler 1974, p.75). In medium-grade metamorphic conditions, biotite tends to be aggregated into clots that are visible in the field and feldspar (plagioclase) is characteristically porphyroblastic. Some of the aluminosilicate mineral occurrences shown on the map (back pocket) are taken from Trowell (1977a). Most of the occurrences of those minerals are in intermediate and felsic metavolcanics, a relation also noted by D.E. Vogel (1975) who proposed aluminum concentration may have occurred through original weathering processes.

Superimposed on the regional metamorphism in the southern part of the area is a retrograde metamorphic event as evidenced by the presence of retrograde chlorite and epidote in many of the samples. Trowell (1978) has also noted this same retrograde event to the south in the Sturgeon Lake area. Locally superimposed on the regional metamorphic event is a contact metamorphism most prominent north and just east of Hough Lake where randomly oriented porphyroblastic hornblende and less commonly the presence of biotite clots are found in many of the rock formations. The origin of the contact metamorphic event is not clear but may be related to: (1) the mafic intrusive plug at Staunton Lake in Conant Township (Bond 1979); (2) the Heron Lake Stock north of the map-area (Bond 1977); or (3) an unexposed near surface intrusive body underlying Hough Lake. A thin section from an intermediate volcanic rock taken approximately 1.6 km northeast of Exploration Lake contained porphyroblastic amphibole that was wrapped around by a regional biotite foliation indicating that the regional metamorphic event locally outlasted the contact metamorphic event.

Carbonate alteration is extensively developed in two parts of the map-area: (1) along Kashaweogama Lake associated with the fault zone; (2) in the northeastern part of the map-area in the vicinity of Hough Lake.

Most of the carbonate alteration along the fault zone is centred in the vicinity of Kashaweogama Lake and is present both as discrete, thin, discordant and concordant veinlets and associated disseminations. The veinlets and locally disseminated reddish brown crystals of ankerite are visible in the field. The carbonate alteration in the vicinity of Hough Lake however, is not apparent in the field. The thin sections of samples from this area contained 5 to 8 percent calcite and locally dolomite. The carbonate is present as disseminated anhedral crystals of calcite that form in pockets and locally as discontinuous veinlets. The dimensions of the area affected by the alteration is difficult to outline but an area up to 1.6 to 2.4 km away from Hough Lake and north to Fisher Lake appears to be altered. From the few thin sections examined it is difficult to determine if the carbonate alteration is pervasive, uniformly affecting all of the area or if it is, in fact, confined to local concentrations. Samples 1, 2, 5, 9 in Table 5, taken near Hough Lake (Figure 4, Chart A, back pocket) all have either high CO_2 or H_20 values as a result of this alteration. No other alteration minerals such as sericite or chlorite are associated with the carbonate alteration. The origin of the alteration is not apparent but may be of economic significance (see section on "Considerations in Future Exploration").

STRUCTURAL GEOLOGY

Primary structures such as those used to determine the stratigraphic sequence in the Houghton-Hough Lakes map-area were found to be preserved only in those rocks of low metamorphic rank. In the southern part of the Handy Lake Volcanic Sequence the rocks are extensively recrystallized to medium grade metamorphic rank and stratigraphic tops could not be recognized in this region. In the northern part of the Handy Lake Volcanic Sequence top determinations were obtained from two exposures of pillow structures in mafic metavolcanic flows and from locally graded beds and one exposure of crossbedding within the metasediments. The trend of the stratigraphy is evident from the trend of the metavolcanic and metasedimentary formations; units of marked lithological contrast are interbedded such that they act as marker horizons within this metavolcanic-metasedimentary sequence.

Foliation, Schistosity, and Banding

Foliation is found developed throughout the metavolcanic-metasedimentary sequences. The foliation is defined by the parallel to subparallel alignment of platy minerals (biotite, chlorite, muscovite) and the linear alignment of prismatic amphibole (hornblende, actinolite). In the latter case, the amphibole, although it is contained in one plane (thus, defining a foliation plane), it commonly exhibits a random orientation within that plane, plunging in varying degrees and does not, therefore, define a lineation. Commonly, the plunge of the amphibole prisms is subhorizontal and its direction of plunge is hard to determine. Foliation of these minerals is most evident in metavolcanics of low-grade metamorphic rank; rocks of medium-grade metamorphic rank are commonly finely recrystallized and appear massive. Primary features such as volcanic fragments and pillow lavas are generally aligned in the plane of foliation and their elongation on plan surface further accentuates the foliation. This foliation is generally parallel to subparallel to the trend of the stratigraphy. Locally, a second foliation is found to be oriented at an acute angle, slightly counter-clockwise (approximately 20 to 30 degrees) to the trend of the first foliation; this represents a younger, crosscutting slaty cleavage that is related to the folding.

Locally, the metavolcanics are schistose. In most places the schistosity occurs in thin (up to several centimetres) zones that, in general, parallel stratigraphy. Locally, these thin shear zones are discordant to the trend of the stratigraphy as observed along Kashaweogama Lake. Schistosity is most intense and most extensive along Kashaweogama Lake where it is related to faulting.

Banded structures are found as parallel, lenticular to discontinuously banded, complementary intermediate and mafic components within the mixed metavolcanic unit south of Hough Lake and in the granitic intrusion at Fairchild Lake. Both primary and secondary banding are represented in the Houghton-Hough Lakes area.

Within the mixed metavolcanic unit south of Hough Lake, banded structure is used to define the surface trend of the linear mafic clot structures. This band-

ing signifies the discontinuous layering resulting from successive accumulations of the two (mafic and intermediate) components and is considered to be in part a primary layered structure. The distribution and scale of the banding varies haphazardly from a few centimetres to approximately 0.6 to 1.8 m on any given exposure. Individual platy minerals (hornblende in the mafic clots and biotite in the intermediate hosts) tend to be randomly oriented within both components. In most cases the trend of the banding of these two components is parallel to subparallel to the overall trend of the mixed volcanic unit as a whole. Near the axis of the major fold structure near Evans Lake the mafic bands are contorted and plunge sympathetically to the major fold structure.

Northwest of Island Lake, within the westward termination of the same mixed metavolcanic unit, banding symbols define thin lenticular to discontinuous banding of a different nature. There, the thin zones of alternating mafic and felsic lenticles to bands are composed of chlorite, chlorite-biotite, quartz, and feldspar. Segregation of these minerals is not complete as observed in thin section; instead, they tend to form discontinuous, diffuse bands rich in one mineral relative to another similar to a gneissoid texture. The scale of this banding is much smaller (1.2 cm on the average) than the first type described previously. The nature of this segregation of the mafic and felsic mineral components is regarded to be due to secondary processes, i.e. either metamorphic or possibly hydrothermal alteration.

Banding is also present within the felsic plutonic rock at Fairchild Lake. The bands are fairly mafic (biotite-rich) and probably originated in part as hybrid zones, and in part by cataclastic remobilization and segregation of mafic and felsic components from a previously homogeneous body. Some of the mafic banding is also augmented by swarm-like, concordant injections of more potassic (quartz monzonite) dikes metasomatically introduced into less potassic (granodioritic) rocks. The banding tends to be fairly continuous, is diffuse in nature, and haphazardly distributed. The scale of this banding varies from 15.2 to 45.7 cm.

Cataclastic Foliation

Cataclasis is widely developed within the Fairchild Lake Intrusion as evidenced by the presence of 1) abundant, locally sigmoidally deformed potassium feldspar augen within a protomylonitic texture, 2) locally developed pseudotachylite, and 3) mylonitic and rare ultramylonitic textures. Protomylonitic texture (with 10 to 50 percent matrix, Spry 1969, p.229) is the most widely developed and is commonly associated with potassium feldspar augen. Mylonite texture (50 to 90 percent matrix, Spry 1969, p.229) and rare ultramylonite (90 to 100 percent matrix, Spry 1969, p.229) are also present but less abundant than protomylonite. In the field the latter types are conspicuous as dark bands varying in width from 1.5 to approximately 60.9 cm. Pseudotachylite is developed along fractures that cut across and are associated with both the protomylonite fabric and adjacent mylonite fabric.

Three different trends of the cataclastic foliation are apparent within the intrusion.

1) Along the south margin there is predominantly an east- to northeast-trending cataclastic fabric that is parallel to and related to the Kashaweogama Lake Fault.

2) Along the northwestern margin and locally along the southern margin a northeast-trending cataclastic fabric is a reflection of several other similar trending fault systems outside of the map-area i.e. the Savant Lake Fault (Bond 1977; 1979), see Miniss River Fault Zone (Hudec 1965), and the Medcalf-Dawson Lake Fault (Breaks and Bond 1977).

3) Along the northeast margin of the intrusive body there is an east-southeast-trending cataclastic fabric. This cataclastic fabric may be either related to adjustments that occurred, penecontemporaneous with the intrusion of the Fairchild Lake Intrusion itself or by later cataclasis related to the Kashaweogama Lake Fault.

Lineation

Secondary lineations within the map-area consist of mineral lineations, deformed volcanic clasts, minor fold axes, deformed conglomerate clasts, and orientation of minor fold structures exhibited by the mafic clots within the mixed metavolcanic unit. These lineations are not commonly observed in the Houghton-Hough Lakes area largely because of poor exposure and flat-lying outcrop areas.

Mineral lineations are defined by subparallel alignment of predominantly prismatic hornblende and lath-shaped plagioclase feldspar. The direction of elongation of volcanic fragments at Shoehorn Lake and the elongation of clasts within the conglomerate at Fairchild Lake were measured. The mafic clots within the mixed metavolcanic unit in the southeastern part of the map-area are deformed and are commonly lineated. Lineation of amphibole is prominent along the margin of these clots and this mineral orientation is the same as the lineation defined by the form of the clots themselves.

Nearly all of these lineations generally plunge from 50 to 70 degrees to the east to east-northeast. A few lineations observed in the southeastern part of the map-area plunge to the east-southeast whereas a few along Kashaweogama Lake plunge to the west. The latter two variations in plunge direction are related to nearby granitoid intrusions.

Folding

REGIONAL SETTING

South of Kashaweogama-Fairchild Lakes the Handy Lake Volcanic Sequence occupies the western limb of a major anticlinal fold. The Jutten Volcanic Sequence north of Kashaweogama Lake and the overlying conglomerate are in fault contact with the Handy Lake Volcanic Sequence. Moore (1928), Rittenhouse (1936), and Skinner (1969) were of the opinion that the entire sequence of

supracrustal rocks in the Savant Lake area formed a major synclinal structure. However, top determinations in the Houghton-Hough Lakes map-area and in Conant Township (Bond 1979) indicate that the Handy Lake Volcanic Sequence forms an anticlinal structure plunging east in the present map-area to east-northeast in Conant Township. The anticlinal structure is flexually folded about a steeply east-dipping fold axis that is curvalinear; in the southeastern part of the map-area the apparent fold axis trends N25E but flexes eastward to N80E in southwestern Conant Township. This drastic change in apparent direction may have been caused by the intrusion of the Jutten Batholith (Bond 1979) southeast of this folded metavolcanic-metasedimentary sequence.

MINOR FOLD STRUCTURES

Except for the metasedimentary units there is a paucity of marker horizons and few minor fold structures were observed. However, the author believes that the Handy Lake Volcanic Sequence and the Jutten Volcanic Sequence in the map-area, form relatively undisturbed homoclinal sequences.

According to company maps of The Algoma Steel Corporation Limited (Assessment Files Research Office, Ontario Ministry of Natural Resources, Toronto) and previous detailed mapping by the author (Bond 1977; 1979), the band of ferruginous metasediments just north of Shallow Lake in the northeastern part of the map-area is continuous with and forms the south limb of an isoclinally folded iron formation exposed in southwestern McCubbin Township. The folded iron formation forms a near vertical plunging syncline with closure to the east. The axis of this synclinal structure trends approximately east-west and is situated approximately 0.8 km (½ mile) north of Shallow Lake. A few small scale sympathetic folds of Z shape are present in the other ferruginous metasedimentary units to the south but, in general, such structures are uncommon. West of Fisher Lake a Z-type fold was found to plunge approximately 70 degrees east which is in agreement with the majority of the lineations observed in the map-area.

Numerous sharp changes in strike of many of the map-units in the vicinity of the major fold axis near Evans Lake indicate more complex parasitic folding in the nose of the fold. The scale of this folding ranges in amplitude from several centimetres up to a thousand metres or more although the larger amplitudes (approximately 100 m) are more common. The smaller scale folding is generally fairly tight or isoclinal whereas the folding characterized by larger amplitudes is relatively open. In the southeast the felsic metavolcanic units provide the best marker references for this folding but, in general, the lack of mappable, continuous marker horizons, insufficient exposure, and metamorphic grade have tended to hamper deciphering the actual fold pattern within this area. The axes of these minor folds are parallel to subparallel to the major anticlinal fold axis and it is obvious the former are directly related to the latter. Due to the small scale nature of this folding it was not possible to graphically represent it on the accompanying map and this explains the apparent highly discordant variations in strike of both primary and secondary structures and some undulatory changes in the plunge of lineations in this part of the map-area.

From the configuration of the felsic metavolcanics and the mixed volcanic unit it would appear that a fold axis is also present near Exploration Lake. This fold axis, if present, would be concordant to the formations striking east at Exploration Lake and curving southeast towards Evans Lake. However, because of lack of precise marker horizons and the presence of medium grade metamorphic rank, it could not be ascertained whether this pattern is, in fact, due to folding or more simply represents an interfingering of metavolcanic sequences. The latter explanation would appear to be the most plausible.

Faulting

One major fault and several minor faults have been interpreted in the map-area on the basis of abrupt termination of stratigraphic units and the presence of cataclastic textures. The minor faults recognized thus far tend to strike consistently in a northeast direction and may be partly related to several other major northeast-trending faults recognized in McCubbin and Poisson Townships (Bond 1977). The faults within the present map-area are marked, in part, by linear drainage patterns.

The Kashaweogama Lake Fault is a major structure which extends both westward (Trusler 1975) and northeastward (Bond 1977). It appears to be a fairly late zone of fracturing that was in part structurally controlled along the contact between the Jutten Volcanic Sequence and the Handy Lake Volcanic Sequence. The fault is thought to have developed in response to the major folding event that produced the major antiformal structure exhibited by the Handy Lake Volcanic Sequence. The Kashaweogama Lake Fault is directly observable and is established on the basis of the following criteria:

(1) there is an abrupt change in the trend of lithologies from an east to east-southeasterly direction south of Kashaweogama Lake to the approximately east to east-northeasterly direction exhibited by the trend of the conglomerate;

(2) Kashaweogama and Fairchild Lakes are part of a strong topographical lineament that extends westward and thence southwestward to Sioux Lookout, a distance of approximately 80 km;

(3) the metavolcanics along Kashaweogama Lake are strongly sheared and the southern margin of the granitic intrusion at Fairchild Lake is cataclastically deformed locally exhibiting pseudotachylite. Thin section examination indicates the matrix of the conglomerate is also cataclastically deformed;

(4) the sheared mafic metavolcanics along Kashaweogama Lake commonly exhibit kink bands. Although no statistical study was done, the kink bands were found to trend mostly in two direction at N10E and N45W. Z-type dextral kink bands trending in the latter direction were by far the most prominent.

Due to the lack of continuous surface expression, the position and width of the fault as indicated on the map is arbitrary and it may actually be wider than represented. The fault is longitudinal, subparallel to the trend of the stratigraphy, and consequently the amount of movement is not known. The presence of

kinking suggests horizontal slippage along the fault and the fact that there is no dramatic change in degree of metamorphism north and south of Kashaweogama Lake suggests little, if any, vertical movement has occurred. This concurs with other fault zones north of the map-area (Breaks and Bond 1976) which also appear to be mainly horizontal strike slip. In the Fairchild Lake Intrusion the intensity of the faulting varies; extreme zones of deformation are confined along bands of protomylonite to mylonite and are separated by bands that are less intensely deformed.

The Fairchild Lake Intrusion appears to have three different trends of cataclasis as indicated previously but age differences among these three are not apparent.

The remaining fault zones near Fisher Lake and near the southeastern part of the map-area are all minor transverse faults that generally trend northeast and are based on either the offset or abrupt termination of metavolcanic units. This northeast trend is parallel to several other major faults in the region including the Miniss Lake Fault (Hudec 1965) and the Savant Lake Fault (Bond 1977; 1979) and these minor faults are probably sympathetically related to these. In the map-area, these minor faults are marked by drainage systems. Subsequent mapping south of the map-area (Trowell 1977a,b) indicates the mafic volcanic rocks in the vicinity of this fault have been offset dextrally.

Numerous minor faults are present on the scale of a single exposure but are too small to be represented on the map. These faults are observed to be commonly less than 2.5 cm wide and are generally free of quartz veining; the amount of separation along these faults is generally only a few metres. Near the southeastern corner of the map-area, on the east limb of the major fold, these minor faults are commonly transverse to the trend of the lithologic units. Along Kashaweogama Lake, microfaults were commonly found to strike at N30E but no structures that showed sense of movement were seen.

REGIONAL COMPILATION AND CORRELATION OF THE SUPRACRUSTAL SEQUENCE IN THE SAVANT LAKE AREA

Figure 5 (Chart A, back pocket) is a regional compilation of the Savant Lake area based on the author's detailed mapping (Bond 1974; 1977; 1979), detailed mapping by Trowell (1977a,b), and on reconnaissance mapping by R.P. Sage *et al.* (1974) and Breaks and Bond (1976).

Four volcanic domains have been recognized in the Savant Lake area. Two of these, east of Savant Lake and north of Kashaweogama Lake are underlain by rocks of the Jutten Volcanic Sequence. The remaining two comprise the Handy Lake Volcanic Sequence and the Whimbrel Lake Volcanic Sequence. A thick succession of metasediments here termed the Savant Group (see section "General Geology," this report) is interposed between the Handy Lake Volcanic Sequence and the other three domains. An extensive conglomerate formation occurs along the southeast, northeast, and west margins of the Savant Group metasediments.

The Jutten Volcanic Sequence, composed mainly of pillowed and massive subaqueous, tholeiitic (Bond 1979) basaltic lava flows underlies two areas, i.e.

east of Savant Lake and north of Kashaweogama Lake.

East of Savant Lake, the Jutten Volcanic Sequence faces northwest (Bond 1977, p.52; 1979, p.63). North of Kashaweogama Lake, the Jutten Volcanic Sequence has been folded about an east-northeast-trending vertical, synclinal axis. Two intrusive stocks (the Dickson Lake Pluton and the Heron Lake Stock) have interrupted the southern limb of this synclinal structure. The south limb of this fold lies north of Kashaweogama Lake; there, the strata face north to northeast from west of the Dickson Lake Pluton to the northeastern part of McCubbin Township. Although these two areas are separated by the Savant Group and the Whimbrel Lake Volcanic Sequence the author considers that these rocks are time equivalent based upon the overall similarity in their chemistry and character of volcanism. The Jutten Volcanic Sequence appears to be the oldest sequence of volcanics within the map-area.

The area of felsic to intermediate metavolcanics in northwest Poisson Township and northeast McCubbin Township (Bond 1977, p.23-25) is herein referred to as the Whimbrel Lake Volcanic Sequence.

The Whimbrel Lake Volcanic Sequence situated north of Whimbrel Lake is dominantly comprised of felsic to intermediate pyroclastics and subsidiary massive to porphyritic flows. Compositions of these rocks range from local extremes of andesite to rhyolite but generally are more uniformly dacitic (Bond 1977, p.24). Fragments within the pyroclastics are up to 1 m in maximum dimension and tend to be coarser and more proximally derived than the pyroclastics observed in the Handy Lake Volcanic Sequence. The presence of volcanic bombs in bedded tuffs (Bond 1977, p.24) interpreted to be of ash-fall origin suggest at least part of this sequence may be subaerial. Based on flow-top breccia and graded tuffaceous metasediments near the southwest part, this sequence faces south and conformably underlies the Savant Group Metasediments. The Whimbrel Lake Volcanic Sequence, because it appears to pass conformably upwards into the Savant Group Metasediments, appears to be younger than the Jutten Volcanic Sequence.

The stratigraphic relationship of the Whimbrel Lake Volcanic Sequence and the Handy Lake Volcanic Sequence is uncertain but they would both appear to conformably underlie the Savant Group Metasediments and are both younger than the Jutten Volcanic Sequence.

The Handy Lake Volcanic Sequence differs from the Whimbrel Lake Volcanic Sequence in that it is characterized by more distal facies pyroclastic rocks. Also, the Handy Lake Volcanic Sequence can be subdivided into numerous individual formations having distinct compositions varying from basalt to rhyolite a characteristic of mature, more evolved volcanic sections. The Handy Lake Volcanic Sequence is folded in an anticlinal structure and faces north and east towards the three other volcanic sequences. Extending south into the Sturgeon Lake area the Handy Lake Volcanic Sequence pinches out against a dominantly mafic metavolcanic sequence in the northeast arm of Sturgeon Lake that also faces east (Trowell 1975, p.37).

The differences in volcanic characteristics of the Handy Lake Volcanic Sequence and the Whimbrel Lake Volcanic Sequence may be due to facies change related to transition from distal to proximal depositional environments if these two sequences are in fact equivalent. It is the authors opinion, however, that because of their contrasting styles of volcanism these two sequences cannot be correlated.

The conglomerate and related finer grained metasediments which strike through Savant Lake are unconformably deposited on the Jutten Volcanic Sequence (Bond 1979). The conglomerate and related metasediments along Kashaweogama Lake appear to face south and unconformably overlie the Jutten Volcanic Sequence north of the lake.

The back-to-back relationship of the conglomerate formation and the Jutten Volcanic Sequence along Kashaweogama Lake is best explained by a major unconformity. Thus, the Jutten Volcanic Sequence is believed to be the oldest volcanic sequence and is envisaged as having undergone a major early period of deformation during which part of the sequence north of Kashaweogama Lake was completely overturned before deposition of the conglomerate. Intrusion of the Heron Lake Stock was possibly penecontemporaneous with this period of deformation (Bond 1977, p. 43). Paucity of primary structural features within the Whimbrel Lake Volcanic Sequence makes any interpretation concerning its relationship to the Jutten Volcanic Sequence difficult. Rare top determinations indicate that this sequence faces away from the Jutten Volcanic Sequence and passes conformably upwards into the Savant Group. The intermediate to mafic volcanic formation situated at the top of the Whimbrel Lake Sequence continues along the southern margin of the conglomerate unit striking along Kashaweogama Lake and interfingers with sediments of the Savant Group, suggesting the Whimbrel Lake Volcanic Sequence is at least partly contemporaneous with the deposition of the conglomerate. The deposition of the Whimbrel Lake Volcanic Sequence is thus believed to have occurred after the early deformation period. The time relation of the Handy Lake Volcanic Sequence to the Whimbrel Lake Volcanic Sequence is unknown except that the former is older than the Savant Group.

The conglomerate is believed by the author to have been deposited in a subaqueous environment proximal to the source of detritus and transitional to the Savant Group Metasediments which were deposited from turbidity currents in a subaqueous environment farther from the source of detritus. The Savant Group Metasediments occupy an area, possibly a former basin, situated between the Jutten, Whimbrel Lake, and Handy Lake Volcanic Domains. These volcanic rocks all appear to be older than the Savant Group and thus all may have contributed material to the sediments. The Handy Lake Volcanic Sequence is transitional into (as observed in the northeastern part of the Houghton-Hough Lakes map-area) and conformably underlies the Savant Group sedimentary sequence (as observed in the northeastern part of Conant Township (Bond 1979). In the latter area the volcanic strata and overlying sediments are completely conformable; also there are intermediate to felsic tuffaceous sedimentary horizons similar in composition to volcanic rocks in the Handy Lake Volcanic Sequence interbedded with the clastic Savant Group metasedimentary series (Bond 1979). Similarly, north and northeast of Kashaweogama Lake, the conglomerate and Whimbrel Lake Volcanic Sequence appear to conformably underlie the Savant Group.

Subsequent deformation produced the major antiformal structure exhibited by the Handy Lake Volcanic Sequence. The metasedimentary Savant Group was deformed at the same time as the Handy Lake Volcanic Sequence. The Savant Group, wedged between the volcanic sequences, exhibits a cross-fold structure (Bond 1977, p.52-53) and was more complexly folded than the volcanic strata due to the confining restraints imposed by the volcanic boundaries. Late

stage faulting (Kashaweogama Lake and Savant Lake Faults) occurred in response to the folding event. The Handy Lake Volcanic Sequence and Savant Group were deformed against the Jutten Volcanic Sequence and the conglomerate which behaved as rigid blocks. The relative adjustment during folding caused cataclasis between the two deformed sequences and the two uncompromising sequences giving rise to the Kashaweogama Lake Fault and the Savant Lake Fault. Minor vertical folds (Bond 1977) within the Savant Group Metasediments, evident from reversals in grading near the Savant Lake Fault, may have originated by dragging of the Savant Group against the rigid block of the Jutten Volcanic Sequence to the east. In the Houghton-Hough Lakes map-area, the conglomerate appears discordant to both the Jutten and Handy Lake Volcanic Sequences. This discordance is due to the presence of an unconformity on the north side and subsequent faulting along the south side.

The above interpretation is based partly upon the conclusion that the conglomerates striking along Savant Lake and Kashaweogama Lake respectively are equivalent. Even if these conglomerates are unrelated the unconformable relationships are still present. The conformable south-facing tops on the finer clastic metasediments north of the east end of Kashaweogama Lake still suggest the conglomerate faces south. In other words the author does not feel that a simple homoclinal sequence is present within the Houghton-Hough Lakes area such that the conglomerate overlies the Handy Lake Volcanic Sequence and is in turn overlain by the mafic metavolcanics north of Kashaweogama Lake.

ECONOMIC GEOLOGY

Evidence of early exploration activity in the Houghton-Hough Lakes area is restricted to a few isolated test pits near Kashaweogama Lake. The Savant Lake map-area has been intermittently prospected since the beginning of the 20th century. Emphasis in the early part of the century has mainly centred on gold exploration. Interest in the present map-area dates back to 1906 (Collins 1907) when iron deposits were found in the northwestern part of the map-area. Prior to 1965 only minor base metal exploration was undertaken but, since the 1968 discovery of the Mattabi Mines base metal (Zn, Cu, Pb, Ag) sulphide deposit on nearby Sturgeon Lake (approximately 50 km south of the map-area), exploration targets have shifted from precious metals to the base metals.

In the Houghton-Hough Lakes area, gold, silver, molybdenum, iron, and copper- and lead-bearing sulphides are present. Except for iron in the form of chert-magnetite iron formation which is found in economically interesting concentrations, there have been no ore deposits found in the map-area to date. Sand and gravel deposits associated with the two eskers are fairly extensive in the map-area.

In the Houghton-Hough Lakes map-area the mineralization encountered to date occurs as isolated, minor disseminations within both volcanic sequences. Gold, silver, and, to a minor extent, copper associated with secondary quartz veins and their silicified host rocks are the only types of mineralization encountered in the Jutten Volcanic Sequence north of Kashaweogama Lake. In the

Handy Lake Volcanic Sequence south of Kashaweogama Lake copper- and lead-bearing sulphide minerals are the most common type of mineralization found. Locally gold and molybdenum are associated with these mineral occurrences. Some of these mineralized zones appear to be secondary, possibly of hydrothermal origin whereas others appear volcanogenic, in part stratigraphically controlled, and are primary in origin. Except for the few occurrences along Kashaweogama Lake most of the mineralization has never been documented and a description of the individual mineralized zones follows.

Gold, Silver, Sulphide Mineralization

JUTTEN VOLCANIC SEQUENCE

A silicified mafic volcanic zone is exposed in a test pit (6.1 x 1 x 1.2 m) situated near the northern shore of Kashaweogama Lake approximately 2000 m east of the rapids in the Marchington River between Fairchild and Kashaweogama Lakes. The shear zone trends northeasterly, dips steeply north, varies in width from 3 to 9 m, and is traceable across only the exposed length of the test pit. The silicified shear zone, marked by a rusty limonite stain carries 1 to 2 percent disseminated pyrite and locally exhibits a green malachite stain. A selected sample with the malachite staining taken by the author and analyzed by the Geoscience Laboratories, Ontario Geological Survey analyzed 0.005 ounce per ton gold, 0.35 ounce per ton silver, and 0.02 percent copper.

Farther east, between the north shore of Kashaweogama Lake and the southeast margin of the Dickson Lake Pluton several strippings and test pits exposing numerous thin quartz veins and associated silicified host rocks are situated within mafic volcanic flows. F. Hoey acquired this ground after publication of the Houghton-Hough Lakes preliminary map (Bond 1974) and a more detailed description of the mineralization (minor gold, silver, and copper) is given in the "Description of Properties" (Number 6).

HANDY LAKE VOLCANIC SEQUENCE

Silver-, copper-, and lead-bearing sulphides are the most common form of economic mineralization found in this part of the map-area. They are associated with intermediate and felsic flows with pyroclastic rocks and with quartz-feldspar porphyritic subvolcanic rocks. An attempt is made to classify the individual mineralized zones as either primary (volcanogenic) or secondary but should not be taken as conclusive without further examination. Pyrite is the dominant mineral visible in the field and is associated with all of the mineralized showings.

Thin felsic lenses, especially prominent in the southeastern part of the map-area, just west of Evans Lake commonly carry pyrite concentrations and may be intrusive (secondary) or volcanogenic (primary) in origin. Many of these thin felsic units are less than 3 m wide and are too small to show graphically on the

map. One of these units exposed on the west side of Highway 599 at the extreme south boundary of the map-area contains locally rich pods of pyrite and minor chalcopyrite. A selected sample taken by the author and analyzed by the Geoscience Laboratories, Ontario Geological Survey yielded 0.03 percent copper.

A silicified mafic volcanic zone hosted within a coarse-grained, magnetite-bearing, mafic volcanic flow was found near the small lake approximately 2.4 km south-southeast of the rapids in the Marchington River between Fairchild and Kashaweogama Lakes. The silicified zone is found near the base of the north side of a single exposure; its strike is largely obscured by overburden but appears to trend approximately east-west and dip 30° to 35° south. The zone was traceable for approximately 6 m and had an observed width of 0.6 to 0.9 m although the latter measurement may be greater due to limited exposure. The silicified mafic volcanic rocks contain 5 to 10 percent disseminated pyrite, lesser amounts of magnetite, and minor chalcopyrite. A selected sample taken by the author and analyzed by the Geoscience Laboratories, Ontario Geological Survey contained 0.02 percent copper.

About 1.6 km northwest of Island Lake near its westward termination, the mixed volcanic unit is locally injected by numerous thin quartz veinlets and these zones are also extensively chloritized. The quartz, chlorite, and mafic (amphibolitic) lenses are interlayered on a scale of 0.6 to 1.2 cm and are hosted by intermediate metavolcanics. Thin section examination indicates several periods of deformation including an older contorted foliation cut by a younger straight foliation. Contorted helecitic plagioclase is parallel to the older foliation and indicates the regional metamorphism outlasted the folding deformation, a relation also noted in Conant Township (Bond 1979). The quartz veins and associated chlorite lenses are parallel to both of the foliations. The quartz and chlorite appear to be partly hydrothermal in origin and partly the products of metamorphic differentiation. The mineralization associated within this zone occurs as isolated, randomly concentrated pods and lenses associated with the quartz-rich parts and occurs over an area of several tens of square metres. The sulphide mineralization is marked by a rusty gossan on the weathered surface. A selected sample of the mineralized part taken from an exposure about 1.6 km northwest of Island Lake by the author and analyzed by the Geoscience Laboratories, Ontario Geological Survey anlayzed 0.39 percent copper, 0.2 ounce per ton silver, and 0.005 ounce per ton gold.

The remaining mineral showings discussed below appear to be volcanogenic partly because of their association and/or stratigraphic control and partly due to lack of associated, visible secondary relationships.

Approximately 1.6 km west of Island Lake pyrite-pyrrhotite mineralization was found localized along the contact between mafic flows to the north and felsic flows and tuffs to the south. This mineralized contact zone was observed on two separate exposures situated 1.6 km apart. At the more western exposure the contact is marked by 5 to 10 percent quartz veins with associated pods of pyrite and pyrrhotite that exhibit a rusty gossan. The more eastern occurrence is marked by substantial pyrite mineralization over a width of 3 to 4 m. The zone contains 20 to 30 percent disseminated euhedral pyrite and minor pyrrhotite in a schistose, biotite-rich mafic matrix. A typical sample of this zone taken by the author and analyzed by the Geoscience Laboratories, Ontario Geological Survey indicated only traces of copper, nickel, and chromium. The zone strikes approximately east and dips vertically.

Disseminated pyrite with minor associated gold, silver, and copper sulphide minerals occurs in a zone situated 2.4 km west-northwest of Evans Lake in felsic to intermediate volcanics of questionable pyroclastic origin. The mineralization is concentrated in an area covering approximately 200 m but, due to poor exposure and the degree of metamorphic recrystallization, no apparent trends or contacts of the mineralized zone are apparent in the field. From 10 to 25 percent, disseminated pyrite mark the zone. The gold, silver, and copper sulphide mineralization is not visible in the field. A selected sample of the pyrite mineralization taken by the author and analyzed by the Geoscience Laboratories, Ontario Geological Survey contained 0.02 ounce per ton gold, 0.06 ounce per ton silver, and 0.01 percent copper. The lack of any structural relations and ill-defined nature of the mineralizations suggest this pyrite may have originated from volcanic fumerolic action.

Locally, the quartz-feldspar porphyritic rocks that are believed to be intrusive are mineralized. On the southeastern shore of Hough Lake, approximately 5 percent disseminated pyrite is present in a pink quartz-feldspar porphyry. A sample taken by the author and analyzed by the Geoscience Laboratories, Ontario Geological Survey contained 0.03 percent lead and 0.01 percent molybdenum. The latter mineralogy is not visible in the field. The mineralization is evenly disseminated throughout the exposure. Lesser concentrations of the mineralization may occur in the eastward extension of this porphyry although exposure is poor to absent in Conant Township (Bond 1979). Approximately 1.2 km southeast of Houghton Lake, pyrite, chalcopyrite, and galena occur as veinlets and thin lenses that are localized along randomly oriented fractures in a quartz-feldspar porphyry. The fractures are localized and do not pervade through the entire outcrop. Although a member of the field party reported the presence of galena at this exposure, a sample submitted for analysis to the Geoscience Laboratories, Ontario Geological Survey indicated 0.01 ounce per ton gold, 0.40 ounce per ton silver, 0.03 percent copper, and no lead.

Pyrite is the main indicator mineral of all of the above-described mineral localities. The associated gold, silver, and chalcopyrite mineralization is only rarely visible in the field.

Iron Deposits

The iron formation concentrated in the northeastern part of the map-area is the only potentially economic prospect to date. According to the Pershland Gold Mines prospectus 1957 (Regional Geologist's Files, Ontario Ministry of Natural Resources, Sioux Lookout) the magnetometer survey indicated a 500 million ton iron deposit amenable to open pit extraction. The testing done to date by Ray Ramsay gave favourable results (Bond 1979, p.102) but further work is required to detail exact tonnages.

The remaining iron formation metasedimentary sequences, although they contain iron formation of a similar quality, are thought to be too diluted with interbedded clastic metasediments to be of economic importance. A sample of iron formation taken by the author from the ferruginous metasedimentary unit located midway between Hough Lake and Fisher Lake was analyzed by the Geos-

cience Laboratories, Ontario Geological Survey and found to contain 29.4 percent soluble iron and, therefore, approximately 40 percent magnetite. Using a Davis tube the sample was ground to -400 mesh and from this 88 percent recovery of the soluble iron in a concentrate with a grade of 67.9 percent was achieved.

Sand and Gravel

Both of the eskers and their associated outwash deposits are composed of sand and gravel that are qualitatively suitable for construction foundations. The outwash deposits would appear to be best suited in that they are composed mainly of sand and fine-grained gravel of a uniform grain size; they have a low clast content in comparison to the eskers which are composed of sand, gravel, and pebble-, cobble- and boulder-sized clasts. The outwash sand deposits are fairly well exposed covered only by a thin veneer of overburden. During 1975, the construction of the new road passing through the southern part of the map-area made extensive use of these sand and gravel deposits.

Considerations in Future Mineral Exploration

To date, no significant base metal discoveries have been made in this area. Airborne geophysical surveys have been conducted over the map-area by several companies as reported in the property descriptions. However, extensive overburden, limited access (until the 1975 construction of the road through the southern half of the map-area), and poor exposure coupled with lack of detailed mapping have dampened exploration interests. This mapping program has indicated much of the area is underlain by numerous alternating formations including felsic, intermediate, and mafic metavolcanics and metasediments indicative of an upper volcanic cycle which is regarded to be a high-potential environment for syngenetic base metal sulphide deposits. The presence of base-metal-type mineralization, although meager, is indeed indicated in the map-area; these zones are favourably associated with intermediate and felsic volcanic and subvolcanic rocks.

Sangster (1972) has reviewed some of the environmental requirements of volcanogenic massive sulphide deposits. They include the following:

(1) The presence of alternating, submarine, volcanic sequences of diverse compositions.

(2) The presence of intrusive complexes in the surrounding area also of diversified compositions.

(3) The presence of coarse felsic pyroclastics indicative of a felsic centre.

(4) The presence of quartz and quartz-feldspar porphyritic rocks of questionable (extrusive or intrusive) origin. The association of porphyroid rock types with these deposits is also noted by Hopwood (1976).

(5) The presence of an alteration zone consisting of chloritization, sericitization, silicification, and carbonatization.

Many of these features appear to be present in the Houghton-Hough Lakes area, the most important being the diversification in nature and composition of volcanic and intrusive rock types. It should however be noted that much of the observed pyroclastic materials within this sequence appears to be fairly distal from the source area. Specific areas in the map-area requiring further detailed examination to determine their economic potential include the following.

(1) The mineralized contact zone 1.6 km west of Island Lake (see Handy Lake Volcanic Sequence in section on "Economic Geology") is unquestionably stratigraphically controlled; volcanogenic base metal concentrations were not indicated by the analysis results and sample 12 (Table 5, Figure 4, see Chart A, back pocket) taken from the felsic horizon just below the contact zone shows no evidence of alteration. If anything the analysis results (traces of copper, chromium, and nickel) suggest more of an affinity for mafic and ultramafic related deposits. Nevertheless, the extent of the mineralization should be traced out along the contact if only to see if the economic quality improves.

(2) The large felsic mass just northwest of Evans Lake is composed predominantly of highly recrystallized equigranular to weakly porphyritic felsic flows and is thought to be a felsic centre. It is of interest to note that the coarsest felsic pyroclastic unit seen in the map-area occurs on the southeastern flanks of this mass on the west side of Highway 599. Also worth noting here are the swarms of quartz veins intruded along numerous fractures especially throughout the southern part of this mass. Although the quartz veins appear to be unmineralized they testify to the fact that there has been substantial hydrothermal activity in the vicinity. Locally, there are breccia zones that may have originated by fumarolic action. Fracturing and brecciation of lava flows such as observed with this felsic mass are not unlike those found associated below the "Kuroko" type deposits (Lambert and Sato 1974, p.1224).

(3) Carbonatization appears to have affected much of the area around Hough Lake. The presence of carbonate alteration in the alteration zone of volcanogenic, base metal deposits (Sangster 1972) including the siderite zone at the Mattabi Mine (Franklin *et al.* 1975) on nearby Sturgeon Lake suggests this would be a favourable area to concentrate exploration activities. The coarsest pyroclastic rocks found in the map-area are of intermediate composition and occur near the southern part of Shoehorn Lake.

(4) The coarse pyroclastic sequence situated 0.8 km west of Highway 599 at the south boundary of the map-area contains base metal mineralization (The Savant Lake Prospect See List of Properties No. 5) and is regarded by the author to be one of the more favourable areas for further base metal mineralization.

(5) The association of chlorite with the westward termination of the mixed volcanic unit northwest of Island Lake, including the zone of base metal mineralization is economically significant in that chlorite is reportedly one of the more abundant alteration minerals found with base metal deposits (Sangster 1972, p.19) and this area requires further examination. This chlorite appears to be hydrothermal, associated with quartz veinlets. Retrograde chlorite is found only in the southern part of

the map-area (south of a line adjoining Exploration Lake and Houghton Lake).

(6) The gold, silver, and copper sulphide-bearing quartz veins associated with the mafic volcanic sequence north of Kashaweogama Lake appear to be of a discontinuous nature and have predominantly low erratic values.

(7) The local association of mineralization with the porphyry complexes which appear to be related more to the volcanism than to the later intrusions implies that these rocks are of some economic potential.

(8) The complex tight isoclinal folding associated with the major fold axis in the southeastern part of the map-area may complicate interpretation of geophysical survey results. It will be difficult in deciding whether EM anomalies, if present, are conformable to stratigraphy.

It is some incentive to exploration concerns that, except for the drilling associated with the Savant Lake Prospect (Property No. 5) in the felsic pyroclastics west of Evans Lake, prior to the 1973 field season most of the drilled anomalies in the Handy Lake Volcanic Sequence have centred on the mafic volcanic formation extending from below Hough Lake to near the south shore of Fairchild Lake.

In summary, there are known mineral deposits in favourable associations in the Handy Lake Volcanic Sequence south of Kashaweogama Lake and this part of the map-area is considered by the author to have a high economic potential.

Description of Properties

Figure 6 (see Chart A, back pocket) shows the location of properties for which assessment work has been filed in the Houghton-Hough Lakes area. Except for the F. Hoey Property, the property descriptions are based upon assessment information submitted for the Houghton-Hough Lakes area prior to December 31, 1973. The work done on the F. Hoey claims was reported in 1974. The drill holes situated (1) 0.8 km north of Island Lake, (2) near the south shore of Hough Lake, and (3) just south of the conglomerate south of Fairchild Lake are the only drill holes located in the field; the remaining four drill hole locations have been plotted on the map on the basis of company assessment records.

B.B.M. INVESTMENTS (1)

North of the east end of Fairchild Lake in the northwestern part of the Houghton-Hough Lakes map-area (Figure 6, Chart A, back pocket), B.B.M. Investments held eight claims during the 1973 field season numbered, PA302013, and PA337114-PA337120 inclusive. The claims are underlain by mafic metavolcanic flows and a thin interlayered cherty metasedimentary horizon.

The property was originally staked and explored by Queenston Gold Mines Limited who, in 1958, drilled 16 diamond drill holes all located on claim PA22126 situated just outside the northern limit of the present map-area. A total of 599.8

m were drilled intersecting predominantly mafic to intermediate metavolcanics and diorite. Pyrite, pyrrhotite, and chalcopyrite mineralization was found associated with silicified zones and quartz veins ranging in core length from 0.635 to 17.8 cm and averaging 7.62 cm (Assessment Files Research Office, Toronto; Diamond Drill Report 10, Armit Lake Area). Many of the mineralized quartz veins are described to be in a "diorite". The mineralization is generally indicated to be in seams as fracture fillings. Not all of the quartz veins are mineralized.

B.B.M. Investments staked claim PA302013 in May 1971 and acquired the remaining seven claims in October 1972. Claim PA302013 coincides approximately with the claim on which the 16 diamond drill holes were previously done by Queenston Gold Mines Limited. No exploration work has been reported on this property by B.B.M. Investments. Claim PA302013 was still held by the company on December 31, 1973 whereas the other seven claims lapsed on November 9, 1973.

CAM MINES LIMITED (2)

Cam Mines Limited optioned four separate groups of claims in the Savant Lake area from E.W. Hadley in May 1971. Two of these claim groups lie partly to completely within the Houghton-Hough Lakes map-area. The first group of claims (area 1, Figure 6, Chart A, back pocket), situated entirely within the map-area, is located along the east boundary of the map-area and extends from the north end of Evans Lake northwards for about 3.8 km. This claim group comprises 41 contiguous claims numbered as follows: PA275618-PA275624, PA287652, PA287653, PA288367, PA288368, PA288390 - PA288408, and PA330981 - PA330990.

The second claim group (area 2, Figure 6, Chart A, back pocket) is located mostly south of the southeast corner of the map-area near Evans Lake and comprises 29 contiguous claims. Only five of these claims (PA253493, PA253494, PA253496, PA253499, PA253500) are located within the limits of the Houghton-Hough Lakes map-area. Both of the claim groups are in areas of intermediate and felsic metavolcanics.

Twenty-two of the claims in the second claim group were originally staked in 1970 by J. Kondrat, E.W. Hadley, and R.J. Penny, all of Thunder Bay, Ontario. J. Kondrat, E.W. Hadley, and R.J. Penny optioned the claims to and conducted a ground, combined (VLF) electromagnetic and magnetometer survey for Jorex Limited in 1970. The survey was carried out over a 400 feet grid system of cut lines with readings being taken at intervals of 100 feet. No significant results were obtained by the survey and it was recommended that the exploration program on these claims be discontinued (file 2.266, Assessment File Research Office, Ontario Geological Survey, Toronto). These same claims were then subsequently optioned to Cam Mines Limited.

In a report by Cam Mines Limited dated June 9, 1971 (Assessment Files Research Office, Ontario Geological Survey, Toronto, file 63.2892) it was recommended, on the basis of a nearby favourable base metal showing and underlying, favourable felsic and intermediate rock assemblages, that an exploration program involving geological mapping and geophysical surveys be undertaken over

the two claim groups. No geological mapping was reported by the company but a geophysical survey (file 2.800, Assessment Files Research Office, Ontario Geological Survey, Toronto), including electromagnetic (horizontal loop) and magnetometer methods, was carried out over a grid system of lines cut at 400 feet intervals. A reading interval of 100 feet was employed.

The first claim group (i.e. north of Evans Lake) was found to be characterized by a uniform magnetic expression. Two parallel conductive zones with no accompanying magnetic expression were found to be present over the lake in the north part of the property. Due to their association with water, the company found it difficult to interpret them (file 2.800, Assessment Files Research Office, Ontario Geological Survey, Toronto). Canex Aerial Exploration Limited who held claims over part of this property in 1969 also found a conductive zone associated with this same lake. One other conductive zone was reported in the Cam Mines Limited geophysical survey lying just north of this lake.

A few minor north- to northeast-trending magnetic anomalies were encountered over the second, more southerly group of claims but generally the results were uniform. No electromagnetic conductive responses were found in the part of the second claim group within the Houghton-Hough Lakes map-area. The larger (first) claim group to the north lapsed in the spring of 1974. The five claims of the second group in the extreme southeast corner of the map-area lapsed in February 1973.

CANADIAN NICKEL COMPANY LIMITED [1969] (3)

The Canadian Nickel Company Limited staked four contiguous claims (PA210555-PA210558 inclusive) located 0.8 km south of Hough Lake (Figure 6, Chart A, back pocket) in June 1969. The company conducted a major exploration program throughout the Savant Lake region during the period 1967 to 1971. Although no records were ever filed with the Ministry it is the authors personal knowledge that much of the drilling was a follow up to both airborne and ground geophysical surveys. The property was located over arenaceous and ferruginous metasediments intercalated with mafic, intermediate, and felsic metavolcanics. During June 1969 one diamond drill hole was drilled on claim Pa210558 and was submitted to the Assessment Files Research Office, Ontario Geological Survey, Toronto. The drill hole (209 feet) encountered intermediate metavolcanics with 10 to 70 percent pyrite-pyrrhotite mineralization over a core-length of 2 inches. A further 10 inches contained less than 1 percent disseminated pyrrhotite-pyrite mineralization. These claims were allowed to lapse on June 11, 1971.

CANEX AERIAL EXPLORATION LIMITED - BLACK GIANT MINES LIMITED (4)

The most extensive exploration program on file in the Assessment Files Research Office, Ontario Geological Survey, Toronto within the map-area was conducted in a joint venture by Canex Aerial Exploration Limited and Black Giant Mines Limited during 1969 and 1970. During November and December 1969, a

combined airborne electromagnetic and magnetic survey (file 2.138, Assessment Files Research Office, Ontario Geological Survey, Toronto) was done over an area including most of the present map-area and also the area west to and including Farrington Lake (approximately 6.5 km west of Houghton Lake). The airborne survey was accomplished utilizing a flight interval of ⅛ mile along lines varying in length from 6 to 9 miles. A total of 831 line miles was flown. The aircraft maintained an altitude of approximately 450 feet above ground expression. Thirteen anomalous zones were picked up by the survey.

During January and February 1970 a total of 171 claims were staked in three separate groups. One hundred and fifty-six claims were staked in an area extending from Hough Lake to Fairchild Lake (area 1, Figure 6, Chart A, back pocket). These claims are mostly underlain by mafic and intermediate metavolcanics and minor metasediments and felsic metavolcanics. A group of nine claims (area 2, Figure 6, Chart A, back pocket) underlain by mafic, intermediate, and felsic metavolcanics were staked approximately 1.6 km west of Island Lake. The remaining six claims were located over mafic metavolcanics along Kashaweogama Lake and were mostly north of the north limit of the map-area. Eleven of the thirteen airborne anomalies were located on the ground and all of these were within the 156-claim group (area 1, Figure 6, Chart A, back pocket). A ground geophysical survey, employing (horizontal loop) electromagnetic and magnetic methods, was conducted over each of the anomalous areas on a grid system of cut lines spaced at 400 feet intervals. Readings were taken at intervals of 100 feet. The geophysical survey was supplemented with detailed geological mapping (scale 1:2 400 or 1 inch to 200 feet) on each of the anomalous zones. On the basis of this work, five of the anomalous areas were selected for diamond drilling (file 2.295, Assessment Files Research Office, Ontario Geological Survey, Toronto). Six diamond drill holes were drilled for a total of 1,057 feet. Two of the drill holes, one 0.6 km north of Island Lake and the other 0.3 km west of the junction of the outlet of Moosolf Lake and Fairchild Lake, were located in the field and are shown on the map; the locations of the remaining four holes also shown on the map are approximate from the diamond drill plans submitted to the Assessment Files Research Office, Ontario Geological Survey, Toronto. The drilling intersected predominantly metasediments and intermediate metavolcanics carrying minor amounts of disseminated pyrite, pyrrhotite, graphite, and only specks of chalcopyrite. The last of these claims were allowed to lapse during the 1973 field season.

GOLSIL MINES LIMITED [1963] (SAVANT LAKE PROSPECT) (5)

The Cu-Pb-Zn-Ag mineralized zone situated approximately 1.2 km west of Highway 599 at the south boundary of the map-area was not observed by any members of the field party but was located on the basis of data provided by Trowell (1977a). According to Trowell (1975, p.35) S. Johnston discovered the prospect in 1952. Shklanka (1969, p.169) indicates this as the "Savant Lake Prospect". In 1953 trenching was carried out by an unknown party. In 1958 the mineralized zone was restaked by Lun-Echo Gold Mines Limited who staked four claims (PA21388, PA21389, PA21392, PA21393). They conducted a geophy-

sical survey, further trenching, x-ray diamond drilling, and re-examined the geology of the mineralized zone. The geophysical survey involved both ground magnetic and electromagnetic (vertical coil) methods. According to the assessment records (file 63.978, Assessment Files Research Office, Ontario Geological Survey, Toronto) the mineralization consists of disseminated chalcopyrite, pyrite, sphalerite, galena, and minor pyrrhotite hosted within a chloritic schist zone within a garnetiferous sedimentary gneiss. The report indicates that bedding strikes N35E and dips near vertical. The mineralization occurs over a length of 60 m with a maximum width of 13 m.

Golsil Mines Limited (Figure 6, Chart A, back pocket) drilled eight diamond drill holes (1,942 feet) in the vicinity of the occurrence. The location of the drilling is in some dispute. According to the location map (file No. 10, Evans Lakes Area, Assessment Files Research Office, Ontario Geological Survey, Toronto) submitted as part of the assessment work, the holes were drilled just south of the Houghton-Hough Lakes map-area. A.P. Best of Savant Lake Town has indicated to N. Trowell (personal communication) that the drilling of Golsil Mines Limited was done in the vicinity of the mineralized zone. According to Shklanka (1969, p.169) the mineralized zone extends to a distance of 250 feet and consists of two parallel zones about 15 feet apart each averaging 5 feet in width.

One of the better analyses indicated 1.67 percent Cu, 1.44 percent Zn, 0.28 percent Pb, and 3.46 ounces per ton Ag over a width of 3 m (Shklanka 1969). Trowell (1978, p.70) has further described the zone.

F. HOEY (6)

In 1974 F. Hoey staked 18 claims near the north-central part of the map-area along Kashaweogama Lake (Figure 6, Chart A, back pocket). Several previously excavated strippings and test pits occur on this property. In a report for the Teck Mining Group Limited by J.A. Kelly of Geophysical Engineering Limited (file 2.1883, Assessment Files Research Office, Ontario Geological Survey, Toronto) it is stated that the property was originally prospected in 1960-1961 by a J.A. Hughes representing the Keevil Mining Group. At that time several gold showings were trenched and sampled but gave erratic values and the claims were allowed to lapse. In 1974 F. Hoey restripped and reblasted the trenches, took chip samples, and geologically mapped the pertinent mineralized areas. A magnetometer and VLF electromagnetic survey were done on a scale of 1:2 400 over the property but encountered nothing significant.

The property is underlain by strongly sheared mafic volcanic rocks. The shearing trends northeast and dips 85 to 90 northwest. The author visited the property in 1973 and found a 2 metre wide silicified band with associated quartz veins that contained 10 percent pyrite mineralization over 0.3 m. In the assessment records (file 2.1883, Assessment Files Research Office, Ontario Geological Survey, Toronto), Kelly describes the mineralized zone in more detail.

The quartz veins vary in width from 1 to 2 inches to about 1.0 feet and in length from 3.0 feet to 10.0 feet. Usually the veins and stringers are separated by at least 0.5 to 1.0 feet of pyritized, dark green sericite-chlorite-carbonate schist. The veins appear to occupy narrow, *en echelon* dilatant zones probably caused by weak drag folding in the schisted country rocks.

The mineralization occurs throughout an altered and schisted zone at least 2,600 feet long by 400 feet wide. Within this area alteration of flows and tuffs vary from dark grey-green chlorite-albite to light grey-green sericite-chlorite-carbonate schist apparently associated with mineralized quartz veins.

The chip samples taken by F. Hoey also gave disappointing gold values all less than 0.05 ounce per ton and only traces of copper and silver.

Only pods of disseminated pyrite and minor veinlets of pyrite and pyrrhotite were observed by the author in the test-pit zone.

MID NORTH ENGINEERING SERVICES LIMITED (7)

In 1971 Mid North Engineering Services Limited, on behalf of Nickel Rim Mines Limited, carried out a geophysical survey on a group of 44 contiguous claims in the vicinity of Evans Lake and Boucher Township. Most of the claims are in Boucher Township with only eight of the claims numbered: PA261211, PA261218, PA254499-PA254504 inclusive, being present in the Houghton-Hough Lakes map-area (Figure 6, Chart A, back pocket).

During March 1971 a combined ground (VLF) electromagnetic and magnetic survey was done on a 400-foot grid system with readings being taken at 50 foot intervals. The magnetic expression across the entire area was fairly low and uniform. Four electromagnetic anomalous areas were found but all of these zones were in Boucher Township. Further exploration work was recommended (file 2.464, Assessment Files Research Office, Ontario Geological Survey, Toronto) but no evidence of this being done was indicated in the assessment files. Half of the claims were cancelled on June 25, 1973 and the remaining four claims (PA261211 and PA261218; PA254501 and PA254502) were in good standing as of December 31, 1973. The claim group is underlain by northwest-trending intermediate and felsic flows, tuffs, and lapilli-tuffs with minor felsic tuff-breccia.

NORANDA EXPLORATION COMPANY LIMITED (8)

Noranda Exploration Company Limited has conducted exploration work on two separate properties in the Houghton-Hough Lakes map-area.

The company staked four contiguous claims (PA270861-PA270864 inclusive) situated approximately 3.2 km east of the northeast corner of Houghton Lake (area 1, Figure 6, Chart A, back pocket) in May 1970. The property is underlain by mafic, intermediate, and felsic metavolcanics. Two weak airborne responses on the southern part of the property were not located by ground (JEM) electromagnetic and magnetic surveys. It was recommended (file 2.556, Assessment Files Research Office, Ontario Geological Survey, Toronto) that a vertical loop survey was necessary to try and pinpoint the conductive zone but no further work was recorded. It is interesting to note that the northern part of this property falls across a mineralized (mainly pyrite) contact between felsic and mafic metavolcanics as shown on the accompanying map (back pocket). This ground became open in August 1973.

Noranda Exploration Company Limited also held 28 contiguous claims 1.6 km south of Hough Lake (area 2, Figure 6, Chart A, back pocket). Half of the claim group is in Conant Township (Bond 1976) whereas the following 14 claims, staked in 1971, are contained in the Houghton-Hough Lakes map-area: PA287981-PA287985 inclusive, PA309110-PA309114 inclusive, and PA311439-PA311442 inclusive.

A geophysical survey, involving electromagnetic (horizontal and vertical loop) and magnetic methods was accomplished over a 400-foot grid with readings being taken at 100 foot intervals with this interval being reduced to 50 feet in anomalous areas. Several strong conductive electromagnetic anomalous zones with strong magnetic expressions were encountered (file 2.768, Assessment Files Research Office, Ontario Geological Survey, Toronto). Two of these anomalous zones varied in length from 1,200 to 3,600 feet. The property is underlain by iron formation and this is probably the source of the geophysical expressions. These claims were allowed to lapse in April and November 1974.

E. PRIESTON (9)

E. Prieston staked four separate claims in the northeastern corner of the map-area west of the R. Ramsey property in February 1971. Only one claim PA288908 lies within the limits of the present geological survey. The claims are underlain by iron formation and associated arenaceous metasediments. No work was recorded on the property and the claims lapsed in September 1973. The reader is referred to the R. Ramsey Property for a history of the exploration of this ground.

R. RAMSEY (10)
(Kashaweogama Lake Iron Prospect)

During the 1973 field season Ray Ramsey of Barrie, Ontario held a group of 12 partly contiguous claims centred near the northeastern corner of the map-area north of Shallow Lake. Most of these claims lie to the north and east just outside of the map-area and only two claims (PA295108, PA3446607) are within the limits of the present geological survey (Figure 6, Chart A, back pocket). Claim PA295108 was staked in November 1970 whereas the remaining 11 claims were staked in December 1972. The property is underlain predominantly by ferruginous and arenaceous metasediments.

The history of this property extends back as far as 1906 and has been reviewed by Bond (1977, p.60):

> The deposit was first examined by Collins (1907) and later, and in more detail by Moore (1910, 1928). In 1908 some test pits were dug and stripping was done, and in one place a shaft was sunk for 15 to 20 feet [4 to 6 m] by a United States-based company on the southern shore of Kashaweogama Lake west of McCubbin Township. In 1921, a magnetometer survey and a dip needle survey (Assessment Files Research Office, Ontario Division of Mines, Toronto, File 63.2932) were done over the area to see if there was any lateral continuity to the iron formation. This survey was done along 26 lines run across the lake with measurements of the intensity being taken at intervals of approxi-

mately one chain (66 feet; 20 m). All of that part of Kashaweogama Lake within McCubbin Township was covered but the survey also extended further west out of the map-area. The surveys showed that the zone of iron formation zone in southwestern McCubbin Township was not continuous with the band of iron formation near Snowbird Lake....

No further work was recorded on the property until June 3, 1955 when Pershland Gold Mines Limited acquired from Wiggle Creek Prospecting Syndicate 19 unpatented claims located in the present map-area, southwest McCubbin Township and northwest Conant Township. The property is underlain by iron formation and arenaceous metasediments. At this time a total of 151 claims were staked under the name of Pershland Gold Mines Limited. Beginning in early 1956, Pershland Gold Mines Limited did considerable trenching, drilled four short test holes (138 feet; 42 m or claim TB62234) and did a dip needle survey over the area. Favourable results initiated further exploration work, and in 1957 Sharpe Geophysical Surveys Limited carried out a ground magnetometer survey (Assessment Files Research Office, Ontario Division of Mines, Toronto, File 63.909) for Pershland Gold Mines Limited on 56 claims grouped near the extreme southwest corner of McCubbin Township. A magnetometer survey was done on grid lines spaced at intervals of 400 feet over the property and observations were taken at intervals of 100 feet and at 50 feet intervals in anomalous zones. The results showed the strongest magnetic attraction to be situated in the extreme southwestern part of McCubbin Township in the eastern part of the property and indicated a band of iron formation between 400 and 700 feet broad with a strike-length of at least 3,000 feet.

In 1957 a further eight holes were drilled but only five (3,002 feet) were submitted to the Assessment Files Research Office, Ontario Division of Mines, Toronto (file 63.2036, page 2). Pershland Gold Mines Limited also stripped parts of the area by bulldozer in 1957. This work was done under the supervision of Ray Ramsey.

All but 21 of the original claims were allowed to lapse. In 1960 Pershland Gold Mines Limited optioned the remaining claims to Caland Ore Company Limited who drilled four diamond drill holes for a total of 2,262 feet in August and September of that year. Two of the holes were situated just north of Shallow Lake in the Houghton-Hough Lakes map-area. The claims reverted back to Pershland Gold Mines Limited.

In 1965 Pershland Gold Mines conducted a more detailed magnetometer survey (Toronto Assessment Files 63.2036) plus a geological mapping program on the 20 claims in order to have more control for any future drilling program. The readings in the detailed magnetometer survey were taken every 25 feet along grid lines spaced at 100 feet intervals and the survey covered only a part of the 1957 magnetometer survey. The survey utilized a Sharpe MF-1 Fluxgate Magnetometer. It was concluded that further drilling and test work was required before it would be possible to determine the economic potential of the iron ore deposit. In 1967 the property was optioned to The Algoma Steel Corporation Limited.

In 1967, The Algoma Steel Corporation Limited acquired from Pershland Gold Mines Limited, 21 claims encompassing the iron formation body in the extreme southwestern part of McCubbin Township. A magnetometer geophysical survey (Assessment Files Research Office, Toronto, File 63.2159) was conducted to confirm widths of sections previously determined by Pershland Gold Mines

Limited in 1957 (Assessment Files Research Office, Toronto, File 63.909).

A geological survey was also done (Assessment Files Research Office, Toronto, File 63a-529) although the bedrock as a rule is poorly exposed. The claims were allowed to revert back to Pershland Gold Mines Limited and the claims were allowed to lapse in 1970.

Ray Ramsey has not recorded any exploration work on the two claims lying specifically within the map-area. However, Ramsey sampled the iron formation on two claims (PA295106, PA295109) situated directly north of the northeast corner of the map-area during July 1971. The sampling program involved the extraction of samples totalling 600 pounds and these were submitted for beneficiation tests. The 600-pound bulk sample analyzed from 33 to 38 percent iron. Preliminary tests (Assessment Files Research Office, Toronto, File 2.838) indicated favourable methods of separation of the iron and a full-scale test program was recommended to determine the optimum conditions for making the separation. The full-scale test program demonstrated that an iron superconcentrate containing greater than 69.5 percent Fe could be produced from sample material that had been ground to -400 mesh in two passes of magnetics. Using a "Jones Separator" greater than 90 percent of the iron was recoverable. The superconcentrate contained about 2 percent SiO_2. Phosphorous (0.022 percent), sulphur (0.005 percent), vanadium ($<$.02 percent), and titanium (0.041 percent) were found to be within acceptable limits. The claims were still in good standing as of December 1973.

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